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# BULLETIN

OF THE

## AMERICAN PHYSICAL SOCIETY

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PROGRAMME OF THE

## CHICAGO MEETING

AT

THE UNIVERSITY OF CHICAGO

Chicago, Illinois

December 29–30–31, 1947

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of the

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DECEMBER 29, 1947 Vol. 22, No. 6

# BULLETIN

OF THE

# AMERICAN PHYSICAL SOCIETY

## CHICAGO MEETING, DECEMBER 29–30–31, 1947

THE **282d meeting of the American Physical Society** is to be held at Chicago, in the buildings of the University of Chicago, on Monday, Tuesday, and Wednesday, December 29, 30, and 31, 1947. This is **not the Annual Meeting** (which will be held in New York at the end of January): it is scheduled partly so that we may hold joint meetings with the American Association for the Advancement of Science—hereinafter denoted by AAAS—and profit by its other sessions, and partly to compensate for the transposition of the autumn meeting from Chicago to Houston. The American Association of Physics Teachers (hereinafter denoted by AAPT) and our own Division of High-Polymer Physics, will hold concurrent meetings.

**Hotel accommodations.** This being the first meeting of our Society in conjunction with the AAAS which the Secretary has ever arranged, he was not aware of the special technique adopted by the AAAS for handling hotel reservations, and the relevant letter miscarried. He was informed in the spring that the AAAS had chosen the Palmer House for our members, and accordingly directed them to write to that hotel: this was the wrong thing to do. All reservations are to be made by writing to the AAAS Reservation Centre, Chicago Convention Bureau, 33 North LaSalle Street, Chicago 2, Illinois. Members who followed instructions to write to the Palmer House, and were turned down, should immediately follow these new instructions.

The **campus of the University of Chicago is reached** from the Palmer House and other Loop hotels by going to the Randolph Street or Van Buren Street stations of the Illinois Central Railroad (east of Michigan Boulevard) and taking any train except those marked "Special." Get off at the station exhaustively marked "55th-56th-57th Streets," walk to the 57th Street or sound end of the platform, and then walk half-a-mile westward. (A taxi may sometimes be found just east of the 56th-Street exit.) Mandel Hall is at the southwest corner of 57th Street and University Avenue, Eckhart and Rosenwald halls are near the centre of the campus, Oriental Institute on the east side of the campus at 58th Street and University Avenue, and Judd Hall on the east side of the 5800 block of Kimbark Avenue two streets eastward from the campus.

The **registration desk of the American Physical Society** (not to be confused with any which the AAAS may set up!) is to be located on the second floor of Eckhart Hall. Members and guests are asked to register. Dinner tickets will be sold there and there only: do not attempt to get them through the AAAS.

A **joint symposium of our Society and of Section B** of the AAAS, on the topic **"High Altitude Research by Rockets,"** has been arranged by a group headed by F. L. Whipple, and will be held on Monday morning and afternoon in Mandel Hall.

A **joint symposium of our Division of High-Polymer Physics and of Section B** of the AAAS, on the topic **"Physics of Polymers of Biological Interest,"** has been arranged by the Division (programme chairman, J. W. Liska) and will be held on Tuesday morning in Judd Lecture Hall. (Take note that it opens at the hour, unusually early for our Society but chosen by the Division,

of 9:00 A.M.) Other sessions of the Division occur in the same hall on Monday morning and afternoon, and on Tuesday afternoon.

**Invited papers** on nuclear physics will be presented in the Oriental Institute on Tuesday afternoon in sequence to the **address of L. A. DuBridge** as retiring vice-president of Section B. An invited paper on solid-state physics will precede the session of contributed papers to be held on Tuesday afternoon in Eckhart Hall.

**Contributed papers** will be presented in six sessions on Monday, on Tuesday and on the morning of Wednesday. Confronted by a difficult decision, the Secretary chose to make them compete with symposia and invited papers in preference to obliging our members to remain throughout Wednesday afternoon.

The **AAPT** will hold its meetings in Kent Theatre: they include a symposium, **"Microwaves and their Uses,"** scheduled for Wednesday morning, and the Richtmyer Memorial Lecture (to be given by H. L. Dodge), and the presentation of the Oersted Medal.

The **dinner** of the American Association of Physics Teachers, in which our Society is cordially invited to join, will be held on Tuesday evening at seven in International House, on East 59th Street at Dorchester Avenue. The price will be $2.90, and tickets will be on sale at the registration desk of our Society up to noon of Tuesday. (Those who wish to reserve their places in advance should use the form on the inside back cover page.) There will be an after-dinner address on the topic "Bows and Arrows," by P. E. Klopsteg.

The **Sigma Pi Sigma luncheon** for members and guests of this fraternity will be held on Tuesday at 12:30 in the Quadrangle Club, 1155 East 56th Street. Tickets will be sold at the registration desk of our Society until 10:00 A.M. of that day; advance reservations may be made by writing to Professor M. W. White at State College, Pennsylvania.

**The Council of the American Physical Society** will meet at 3:45 P.M. on Tuesday in Eckhart Hall, Room 316, unless contrary notice is sent to its members.

The **AAAS** is anxious to have our members register with it. No compulsion will be exerted by our Society, but its members may desire to acknowledge the advantages of these joint sessions of ours with the AAAS and of the other sessions of the AAAS by acceding to the request. Also, those who do not register with the AAAS may find themselves excluded from those of its sessions in which the American Physical Society does not participate, and even from those of the AAPT. Registration costs $2 for members and $3 for non-members (of the AAAS) and may be made in advance by sending the appropriate check to the AAAS at 1515 Massachusetts Avenue, Washington 5, D. C. Those who thus register by mail receive the complete programme of the AAAS by mail.

## General Rules Relating to Papers

The By-Laws of the Society stipulate that no contributed paper may be accepted for presentation at any meeting of the Society unless the titles and an abstract of the paper are delivered to the office of the Society not later than the deadline date stated in the printed call for the meeting. The time allowed for the oral presentation of a contributed paper is ten minutes at most. When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the first named in its title.) For each paper on this programme the Secretary indicates a session at the end of which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may rule that it is to be read by title.

Titles and abstracts of the contributed papers accepted for this meeting are given in the following pages. Proofs of these abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of the *Physical Review*.

KARL K. DARROW, *Secretary*
American Physical Society
Columbia University
New York 27, New York

# PROGRAMME

MONDAY MORNING AT 10:00

Eckhart Hall, Room 113

(A. J. DEMPSTER presiding)

**A1. Total Cross Sections of Fe, Ni, and Bi for Fast Neutrons.** C. K. BOCKELMAN, L. W. SEAGONDOLLAR, AND H. H. BARSCHALL, *University of Wisconsin.*—A continuation of previous work on the scattering of fast neutrons as a function of neutron energy[1] has been undertaken. Neutrons of continuously variable energy were obtained by bombarding a thin Li target with protons. The total cross sections of Fe, Ni, and Bi have been measured over the 10 kev to 500 kev energy range with a resolving power of 20 kev, and over the 200 kev to 1500 kev range with a resolving power of 150 kev. With the higher resolution, definite maxima and minima were found for Fe and Ni, but not for Bi. These data are in good agreement with previous measurements obtained by use of photo-neutron sources.[2] With the lower resolution, the total cross section for each of the three elements was found to decrease monotonically as the neutron energy increased. A comparison of the experimental results with predicted values[3] will be made.

[1] Seagondollar and Barschall, Phys. Rev. **72**, 439 (1947).
[2] Fields, Russell, Sachs, and Wattenberg, Phys. Rev. **71**, 508 (1947).
[3] Feshbach, Peaslee, and Weisskopf, Phys. Rev. **71**, 145 (1947).

**A2. Beta Spectra of $Cu^{64}$ as a Test of the Fermi Theory.** C. SHARP COOK AND LAWRENCE M. LANGER, *Indiana University.*—A detailed investigation of the energy distributions of the negatrons and positrons emitted by $Cu^{64}$ has been made under optimum conditions, using a large, scatter-free, magnetic spectrometer of high resolution. The spectrometer uses a radius of curvature of 40 cm and employs a radially inhomogeneous magnetic field to obtain second order focusing in 180° with a resolution of 0.5 percent. Chemically separated, cyclotron sources of high specific activity about 0.2 mg/cm² thick were mounted on a backing support of 0.02 mg/cm². The particles were detected by a counter whose window has a range of 2.5 kev. It is found that for *both* positrons and negatrons, there are more particles at low energy than are predicted by the Fermi theory. The positron distribution begins to deviate from the Fermi straight line at a higher energy than do the negatrons and the deviation is much greater. In addition, the ratio of the number of positrons to the number of electrons is larger than that predicted by the theory for all energies below 0.2 Mev. Whereas the experimental data of Backus covering the region below 50 kev agree with our data over this region, the interpretation of Backus' results by Lewis and Bohm is not consistent with our measurements for the entire energy distribution.

**A3. Momentum Conservation in the Beta Decay of P 32 and the Angular Correlation of Neutrinos with Electrons.** CHALMERS W. SHERWIN, *University of Illinois.*—It is possible, by evaporation of carrier free P 32, to produce what appear to be mono-layer beta active sources. These sources maintain their characteristics for several hours of pressures of about $10^{-7}$ mm of Hg. The momentum of the recoil ion is measured by timing its flight in a field free space. Recoil momentum spectra are observed at 180°, 135°, 90°, and 45° with respect to the electrons. It is shown that (a) momentum is not conserved between the electron and the recoil nucleus; (b) the experimental data are in disagreement with any hypothesis in which the neutrino and the electron are most probably emitted in the same hemisphere; (c) for recoil ions above about 25 ev energy, the observed recoil momentum spectra agree rather well with those spectra calculated on the assumption of a $(1-\beta\cos\theta)$ neutrino-electron angular correlation function; and (d) below 25 ev, too many recoils are observed compared to any neutrino theory which gives agreement for high momentum recoils. Since the reason for the disagreement below 25 ev is not understood, the selection of the $(1-\beta\cos\theta)$ function must be regarded as tentative.

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**A4. $H^3$ and the Mass of the Neutrino.** JOHN R. PRUETT, *Indiana University.*—Tritium appears to have an anomalously short life (10–20 years) for its energy release (11–15 kev). Konopinski* has shown that this could be explained on the basis that an unobserved part of the energy is released in the form of a (anti) neutrino of very small but finite rest mass. He confined himself largely to purely statistical considerations in obtaining an estimate of the (anti) neutrino mass ($\mu$ m) needed (1/45 to 1/30 of the electron's rest mass m). At least two fairly important factors were ignored by him: the influence of the Coulomb field on the electron and a relativistic correction factor which arises from the summation over spins of the emitted particles, $1-(\mu/WK)$. Here $W$, $K$ are the total energies of each particle in units of $mc^2$. When these factors are taken into account, one finds that considerably larger values of $\mu$ are needed than those estimated by Konopinski. Taking 20 years for the half-life and making the comparison to $He^6$ as done by Konopinski, one finds $\mu=0.277$ if the energy release is 11 kev, $\mu=0.054$ if 15 kev. No neutrino mass would need to be assumed if the energy released were found to be as high as 20 kev. The influence of the



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neutrino mass on the shapes of the $H^3$, $C^{14}$ and other spectra will also be discussed.

* E. J. Konopinski, Phys. Rev. **72**, 518 (1947).

**A5. Short Lived Metastable State in an "Even-Even" Nucleus: $Ge^{72}$.** J. C. Bowe, M. Goldhaber, R. D. Hill, W. E. Meyerhof, and O. Sala,* *University of Illinois.*—Among the radiations of $Ga^{72}$ (14.1 hr), which decays to $Ge^{72}$, internal conversion electrons corresponding to a transition of 0.72 Mev have been noticed by M. Deutsch and K. Siegbahn (private communication). Using delayed coincidences, we find that internal conversion electrons with a range in Al of $\sim$240 mg/cm$^2$ are emitted from an excited state of $Ge^{72}$ with a half life period of $(5\pm0.5)\times10^{-7}$ sec. These electrons follow a weak beta branch of $Ga^{72}$ with an intensity of the order of 1 percent. We have been unable to detect delayed gamma rays and we conclude that at least 50 percent of the delayed transitions are internally converted. These facts are compatible with the assumption that we are dealing here with a $0\rightarrow0$ transition with no change of parity, similar to the classical case in RaC′ first investigated by C. D. Ellis and R. H. Fowler. For such a transition no gamma ray emission is possible and the excitation energy is transferred by direct interaction from the nucleus to an electron of the $K$, $L$ or higher shells. No good agreement between experiment and theory can be obtained if other types of isomeric transitions are assumed (e.g. $\Delta l=2$, 3 or 4).

* Rockefeller Fellow of the University of Saõ Paulo, Saõ Paulo, Brazil.

**A6. Multiple Nuclear Isomerism.** E. Der Mateosian, M. Goldhaber, C. O. Muehlhause, and M. McKeown, *Argonne National Laboratory.*—In the course of an investigation of the activity induced in Sb by slow neutrons we noticed three previously unobserved short periods with the following half lifetimes: 1.3 min., 3.5 min., and 21 min. Their saturation intensities are of the order of a few tenths of one percent of those of the known activities, $Sb^{122}$ (2.8 d.) and $Sb^{124}$ (60 d.). Using a sample of Sb enriched in $Sb^{123}$ (96.3 percent $Sb^{123}$ we found that the 1.3 and 21 min. periods are both due to isomers of $Sb^{124}$ (60 d.) and that the 3.5 min. period is due to an isomer of $Sb^{122}$ (2.8 d.). Characteristic $K\alpha$ radiation of Sb was found to be associated with the 3.5 min. period, but not with the 1.3 and 21 min. periods. The 3.5 and 21 min. periods both show intense soft electrons with half value thicknesses in Al of 1.7 mg/cm$^2$ and 0.2 mg/cm$^2$ respectively, indicating internal conversion electrons with approximate energies of 110 kev and 14 kev respectively. The isomeric transition of $Sb^{124}$ (21 min.) appears to be of lower energy than the $K$ work function of Sb (31 kev). The 1.3 min. isomer decays with the emission of negative beta rays of $3.2\pm0.2$ Mev maximum energy.

**A7. Coincidence Experiments on $Sc^{46}$ and $Au^{198}$.*** E. T. Jurney and Margaret R. Keck, *Indiana University.*—Coincidence measurements of the type described by Mitchell, Langer, and McDaniel[1] have been made on the isotopes $Sc^{46}$ (85 d.) and $Au^{198}$ (2.8 d.). For $Sc^{46}$ both gamma-gamma and beta-gamma coincidences were found. The ratio of the number of gamma-gamma coincidences per gamma ray counted was $(0.720\pm0.08)\times10^{-3}$. This indicates cascaded gamma rays in the decay scheme. The ratio of the number of beta-gamma coincidences counted to the number of beta-rays counted was constant for absorber thicknesses up to 0.068 gm/cm$^2$. Our results are in agreement with the disintegration scheme proposed by Feister and Curtiss; our coincidence techniques are not selective enough to obtain beta-gamma coincidences involving the high energy, low intensity beta-ray group reported by Peacock and Wilkinson. Earlier measurements on $Au^{198}$ by Clark definitely indicate gamma-gamma coincidences. We repeated this experiment using gold which had been chemically separated and obtained no evidence of gamma-gamma coincidences. The ratio of beta-gamma coincidences to counted beta-rays was found to be constant for absorber thicknesses up to 0.270 gm/cm$^2$, which is in agreement with Clark and with Norling, indicating that the beta-ray spectrum is simple, and leads to an excited state of $Hg^{198}$ from which a gamma-ray of 0.41 mv follows.

* This research was supported by a grant from the Office of Naval Research.

[1] A. C. G. Mitchell, L. M. Langer, and P. W. McDaniel, Phys. Rev. **57**, 1107 (1940).

**A8. Beta and Gamma Rays of $Ga^{72}$.** A. C. G. Mitchell, B. D. Kern, and D. J. Zaffarano, *Indiana University.*—The spectrum of $Ga^{72}$ (14.1 hr.) is being investigated using a magnetic lens spectrometer. The spectrum is quite complicated and to date only the lines of higher intensity are known. Photo-electric lines, using a lead radiator, have been found for which the gamma-ray energy is 0.64, 0.84, 2.15 and one of higher energy. The distribution of the Compton electrons from a copper radiator was studied and gave lines corresponding to gamma-rays at 0.64, 0.71, 0.84 and the high energy lines. In addition there is some evidence for a weak line at 1.48 mv. The beta-ray spectrum shows an internally converted line, gamma-ray energy 0.71 mv. The beta-ray spectrum is complex. There are at least three groups with end points at 3.09, 2.2, and 0.79 mv.

**A9. Gamma Radiation from Scandium, Cerium, and Terbium.** J. M. Cork, R. G. Shreffler, and C. M. Fowler, *University of Michigan.*—Spectrometric studies have been made of the radiations from specimens of scandium, cerium and terbium, irradiated in the Oak Ridge pile by the $(n,\gamma)$ reaction the isotopes formed should be $Sc^{46}$ (85 d.), $Ce^{141}$ (28 d.), and $Tb^{160}$ (72 d.). Scandium shows no converted gamma ray but by absorption in copper and lead a gamma line is observed at 1.15 Mev. Cerium has a converted gamma ray of 103.3 kev. Terbium shows many lines due to internal conversion. $K$–$L$–$M$ differences are observed characteristic of the next heavier element, dysprosium, showing the gamma radiation follows beta emission. The lines as identified show gamma rays of 85.6, 194.7, 213.2, and 298.0 kev, and by absorption a gamma ray at 1.10 Mev. In one case conversion due to $N$ electrons is identified.

**A10. On the Emission of Continuous $\gamma$-Radiation during $\beta$-Decay.** C. S. WANG AND D. L. FALKOFF,* *University of Michigan.*—The continuous $\gamma$-ray spectrum due to the sudden change in nuclear charge during $\beta$-decay has been treated by Knipp and Uhlenbeck[1] and F. Bloch,[2] who calculated the bremsstrahlung by second-order perturbation theory in which the perturbing potentials were the Fermi electron-neutrino interaction for the allowed $\beta$-decay, and the electromagnetic interaction for the $\gamma$-emission. Knipp and Uhlenbeck also calculated the $\gamma$-spectrum by first-order perturbation theory assuming the Fermi energy distribution for the outgoing $\beta$-particles and using only the electromagnetic coupling to the radiation field. We have extended these calculations to the different types of $\beta$-interactions and to various orders of forbiddenness and find, contrary to a remark of Morrison and Schiff,[3] that the two methods give essentially the same result: The $\gamma$-spectrum has practically the same shape, and the ratio of the total $\gamma$-intensity to $\beta$-energy is the same for forbidden as allowed transitions. We are able to account for this by consideration of a simple classical analog for the bremstrahlung.

* National Research Council Pre-doctoral Fellow.
[1] J. K. Knipp and G. E. Uhlenbeck, Physica III, 425 (1936).
[2] F. Bloch, Phys. Rev. **50**, 272 (1936).
[3] P. Morrison and L. I. Schiff, Phys. Rev. **58**, 24 (1940).

**A11. Introduction of Two Neutrons into Atomic Nuclei under $H^3$ Bombardment.** D. N. KUNDU AND M. L. POOL, *Ohio State University.*—$H^3$ particles have been used for the introduction of two neutrons into atomic nuclei. The $H^3$ was produced by bombarding Be with 10-Mev deuterons as previously reported. The target was metallic Rh and Co placed immediately behind the Be foil. After chemistry, the Rh fraction of the first foil showed the 35-hour $Rh^{105}$ activity. The activated layer of the bombarded Co block was etched out with nitric acid and the Co fraction showed the 1.75-hour $Co^{61}$ activity. Beta-energy measurements by absorption in aluminum gave as the maximum values 0.6 Mev for the 35-hour Rh and 1.1 Mev for the 1.76 hour Co. No gamma is emitted by Co in the 1.75 hour period. The possibility that the activities are produced by ordinary neutrons from the Be has been excluded. Since $Rh^{103}$ and $Co^{59}$ are the only stable isotopes of Rh and Co with 100 percent abundance, two neutrons have been introduced into each of the $Rh^{103}$ and $Co^{59}$ nuclei according to the reactions $Rh^{103}(H^3,p)Rh^{105}$ and $Co^{59}(H^3,p)Co^{61}$ respectively. The mechanism appears to be mostly an Oppenheimer-Phillips process with $H^3$. The results indicate a probable evidence of the di-neutron ($_0n^2$).

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## MONDAY MORNING AT 10:00

Judd Lecture Hall

(J. W. LISKA presiding)

### *Invited Papers of the Division of High-Polymer Physics*

**W1. Depolarization of Light Scattered by Macromolecular Solutions.** PAUL DOTY* AND S. J. STEIN, *The Royal Institution, London, and the Polytechnic Institute of Brooklyn.*—The light scattered transversely from a solution through which a parallel beam of monochromatic, polarized light passes, can be readily resolved into vertically and horizontally polarized components. When the incident light is vertically polarized these components in the scattered light are designated as $V_v$ and $H_v$; when it is horizontally polarized the components are denoted by $V_h$ and $H_h$, respectively. A qualitative theory is presented which predicts the variation of these four components with such variables as molecular weight, concentration, molecular size, solvent-solute interaction, and ionic charge. These details are discussed separately for flexible and rigid molecules. The results for the different components can be combined to predict the behavior of the conventionally measured depolarization ratios: $\rho_v$ $(=H_v/V_v)$ and $\rho_h$ $(=V_h/H_h)$. It is clear that less ambiguous interpretations of data are possible if the absolute values of the individual components are measured rather than the ratios as heretofore. The calculation of macromolecular dimensions by measuring depolarization ratios is discussed and several important errors in the literature are corrected. Some measurements on polymer solutions and tobacco mosaic virus solutions under different conditions are presented and interpreted in terms of the theory. In particular, a correlation of orientation in the contacts of polymer segments is noted and a precise test of the calculation of dimensions of rod-like molecules from depolarization measurements indicates the essentially qualitative nature of this relation.

* Present address: Chemistry Hall, University of Notre Dame, South Bend, Indiana.

**W2. Absorption Analysis of High Molecular Substances.** INGRID CLAESSON AND STIG CLAESSON,* *University of Uppsala, Sweden.*—Some preliminary experiments have been carried out in order to investigate the possibilities of using adsorption analysis in the study of high polymeric substances. The experimental arrangements for adsorption analysis developed by Tiselius and one of the present

authors will be described. So far the so-called *frontal analysis* has been used. This means that the solution is forced through a column with adsorbent and the concentration of the effluent is followed continuously with a micro-interference-refractometer. Activated charcoal has been used as adsorbent. It has been possible to show the occurrence of different discrete fractions in nitrocelluloses, polyvinylacetates, and synthetic rubbers. The fractions are similar in molecular weight only as they fail to show up as separate boundaries when the original rather polydisperse solution is ultracentrifugated. The fractions from the adsorption analysis are less polydisperse than the original solution. From a separate study it has been found that the amount adsorbed decreases with increasing molecular weight of the high polymeric substances and the same is true for the rate of adsorption (diffusion effect) which is rather slow. Both these effects will cause the higher molecular species to occur in the first fractions, making it possible to fractionate high polymeric substances according to molecular weight. The separation factor is however not large enough to account for the occurrence of the discrete fractions mentioned earlier. Thus it appears that adsorption analysis makes it possible to fractionate high polymeric substances both according to molecular weight and to other variables.

* Visiting Professor, University of California.

**W3. Elasto-Viscous Properties of Polyisobutylene I: Relaxation of Stress in Whole Polymer of Different Molecular Weights at Elevated Temperatures.** R. D. ANDREWS,[1] N. HOFMAN-BANG,[2] AND A. V. TOBOLSKY.[1]—Stress relaxation in polyisobutylene whole polymers of different average molecular weights has been investigated over the temperature range 30°–100°C at different elongations. The relaxation curve for a given molecular weight, when plotted as "reduced stress" *vs.* logarithmic time, has the same shape at different temperatures, differing only in position along the time scale. Activation energies for relaxation, calculated by use of the Arrhenius equation, are found to be experimentally identical for the different molecular weights, having the average value 15.4 kcals. The shape of the relaxation curve is independent of elongation up to approximately 70 percent elongation; beyond this value the relative decrease in stress between any two arbitrary time values increases with increasing elongation. The relaxation curve does not correspond to exponential, hyperbolic tangent, or exponential integral functions; the experimental points are fit best by a hyperbola. Reciprocal viscosity average molecular weight plotted against the logarithm of the time at which the reduced stress has a certain arbitrary value, at a fixed temperature and elongation, yields straight lines. Relaxation rate depends on molecular weight with sufficient sensitivity so that stress relaxation may be a practical method of measuring the molecular weights of raw polymers directly in the solid state.

[1] Frick Chemical Laboratory, Princeton University, Princeton, New Jersey.
[2] Present address: The Technical University of Denmark, Copenhagen, Denmark.

**W4. The Viscosity of Glass.** HOWARD A. ROBINSON AND EDWARD M. MAN, JR., *Armstrong Cork Company.*—A careful study has been made of empirical formulae which have been proposed connecting the viscosity of glasses with temperature. It is shown that the Waterton equation

$$\eta = A \exp\left[\frac{b_0}{T} e^{B/T}\right],$$

and the Fulcher equation,

$$\eta = A e^{T - T_0},$$

are essentially identical and that both can be made to fit experimental results well within the experimental error from $\log\eta = 16$ down to $\log\eta = 1.5$. Beyond these extremes the formulae diverge. It will be shown that $A$, $B$, and $T_0$, the constants of the Fulcher equation, are linear functions of glass composition. Factors will be presented for the two component $Na_2O - SiO_2$ glasses: Successful applications of these ideas have been made to glasses containing as many as eight components. It is, therefore, possible to calculate the viscosity of glasses of quite wide compositional ranges by means of these empirical factors with an average accuracy of less than five degrees Centigrade for each viscosity point calculated.

**W5. Use of the Electron Microscope in Exploring the Smoothness of Surfaces.** ROBLEY C. WILLIAMS, *University of Michigan.*—The application of the electron microscope in the study of surface detail has been greatly extended in recent months by the improvement of techniques which allow extremely small irregularities to be photographed. It is now possible to discern sharp surface discontinuities of magnitude less than 5 angstrom units. The methods have been used to explore the detail in the surfaces of polymers such as collodion, polyvinyl formal (Formvar), and polythene, and in the surfaces of nonorganic materials such as crystals, thin evaporated films, and glass.

## MONDAY MORNING AT 9:30

Mandel Hall

(M. A. TUVE presiding)

### *Joint Symposium of the American Physical Society and Section B of the AAAS*

#### *High Altitude Research by Rockets*

**1. Introduction: Research by Rockets.** J. A. VAN ALLEN, *John Hopkins University.* Motion pictures. (30 min., discussion 10 min.)

**2. Sky Brightness.** H. A. MILEY, *Air Materiel Command.* (15 min.)

**3. The Measurement of Atmospheric Pressure between the Altitudes of 65 and 110 Km.** W. G. DOW, *University of Michigan.* (15 min.)

**4. Theoretical Considerations of Ambient Temperature Measurements of the Upper Atmosphere.** ERIC BETH, *Air Materiel Command.* (15 min.)

**5. Pressure and Temperature of the Upper Atmosphere.** R. J. HAVENS, *Naval Research Laboratory.* (20 min., discussion 25 min.)

**6. Ionosphere Experiments Utilizing Rockets.** T. R. BURNIGHT, *Naval Research Laboratory.* (15 min.)

**7. The Use of a Beacon to Measure Ion Density in the *E*-Layer.** MARCUS O'DAY, *Air Materiel Command.* (15 min., discussion 15 min.)

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## MONDAY AFTERNOON AT 2:00

Mandel Hall

(J. R. OPPENHEIMER presiding)

### *Continuation of the Symposium on High Altitude Research*

**8. Characteristics of the Sun's Spectrum obtained from V-2 Rockets.** J. J. HOPFIELD, *John Hopkins University.* (15 min.)

**9. Some Aspects of the Solar Spectrum between 3000A and 2300A.** H. E. CLEARMAN, *Johns Hopkins University.* (15 min.)

**10. Solar Ultraviolet Spectroscopy from V-2 Rockets.** R. TOUSEY, *Naval Research Laboratory.* (20 min., discussion 25 min.)

**11. Cosmic-Ray Studies from V-2's.** G. J. PERLOW, *Naval Research Laboratory.* (20 min.)

**12. Cosmic-Ray Bursts in the Upper Atmosphere.** H. E. TATEL, *Johns Hopkins University.* (15 min.)

**13. Direct Measurement of the Flux Charged Cosmic-Ray Primaries.** J. A. VAN ALLEN, *Johns Hopkins University.* (15 min., discussion 25 min.)

**14. Results of Recent Firings.** (Speaker not chosen when Bulletin went to press.) (20 min., discussion 10 min.)

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## MONDAY AFTERNOON AT 2:15

Eckhart Hall, Room 113

(A. C. G. MITCHELL presiding)

**B1. Interpretation of the Triton Moment.** R. G. SACHS, *University of Wisconsin.*—The present status of the interpretation of the triton moment will be summarized. Two distinctly different approaches to the problem have been taken: (1) Villars has estimated the contribution to the moment of the exchange current produced by a pseudo-

scalar meson field and has found it to be adequate. Presumably other types of meson field would also produce the required exchange current. (2) The character of the wave function required to explain the moment in the absence of exchange currents has been determined. It was found in this case that the wave function must contain a large admixture of $^3P$, $^4P$, and $^4D$ states. A measurement of the $He^3$ moment would lead to a clearcut decision between the interpretations (1) and (2), since (1) leads to a $He^3$ moment ten percent greater in magnitude than the neutron moment while (2) leads to a $He^3$ moment no more than six percent greater. A decision in favor of (2) would appear to indicate the existence of strong three body spin-orbit interactions in nuclei since a binding energy calculation has indicated that the tensor interaction would not lead to a wave function containing the required admixture of states. A decision in favor of (1) would seem to be strong evidence for the existence of meson exchange currents in nuclei.

**B2. The Hyperfine Structure of $K^{40}$.*** LUTHER DAVIS, JR. AND JERROLD R. ZACHARIAS. *Massachusetts Institute of Technology.*—The atomic beam magnetic resonance method has been used to determine the hyperfine structure $\Delta\nu$ of $K^{40}$ and to make a positive assignment of the results to the nucleus of mass 40. The apparatus used in these measurements was similar to that described by Zacharias, but with the addition of a mass spectrometer in place of the usual surface ionization detector, which in this case serves as the source of ions for the mass spectrometer. The mass spectrometer reduces the general background due to other alkali atoms in the apparatus and other isotopes of potassium in the beam. The entire apparatus has been designed for measurements with artifically radioactive nuclei, such as $Na^{22}$, and a special oven with a long exit canal was used to conserve material. At mass number 40 transitions were observed at weak field and low frequencies (2 to 8 Mgc) which correspond to an alkali atom with a nuclear spin of 4. A resonance at 1285.745 Mgc in a field of 2.58 gauss and another at 1285.774 Mgc in a field of 3.37 gauss when weighted yield a value of the $\Delta\nu$ for $K^{40}$ of $1285.73\pm.05$ Mgc. This confirms previous results.

* This work has been supported in part by the Signal Corps, the Air Materiel Command, and the Office of Naval Research.

**B3. An Ion Source for Isotopic Mass Comparisons.** A. E. SHAW, *Argonne National Laboratory.*—Experiments have been continued with the source of positive ions described in a previous paper[1] in which solid samples were heated in a tungsten crucible to a high temperature by electron bombardment. It was found that a fraction of the bombarding electrons may be used to ionize neutral atoms as they leave the crucible. Ionized atoms with all charges up to six have been observed with 500 volt electrons. This source is suitable for comparing the masses of the isotopes of heavy elements with those of the light elements for which more accurate masses are known. Preliminary observations have been made with a double focusing mass spectrograph on the doublet, $Cu^{+1}-Pt^{+3}$, at mass 65. Uranium ions with four charges appear at the equivalent mass 59.5 and have been compared with the nickel masses. Platinum with six charges can be compared with the oxygen molecule at mass 32; and platinum with five charges with potassium 39.

[1] Phys. Rev. 71, 277 (1947).

**B4. The Packing Fraction of Zirconium.** WILFRID RALL,* *Metallurgical Laboratory.*—The packing fraction of the zirconium isotopes, relative to uranium, has been determined directly. Mass spectra permitting comparison of doubly charged zirconium ions with quintuply charged uranium ions were obtained with a double-focusing mass spectrograph of the type used by Dempster[1] with a spark as source of ions. Since quintuply charged uranium-238 occurs at 47.6, only the zirconium isotopes at 46, 47, and 48 were measured. The zirconium-uranium packing fraction difference was calculated from measurements of eighteen mass spectra, on the assumption that it was the same for the three zirconium isotopes. The value obtained was $-(12.1\pm0.9)\times10^{-4}$. This agrees, within the experimental error, with the curve given by Dempster,[1] since his value of $5.6\times10^{-4}$ for uranium gives $-(6.5\pm0.9)\times10^{-4}$ for zirconium. However, more precise measurements are necessary fully to check the smoothness of the packing fraction curve in this region. Evidence for a source of error inherent in the method of obtaining these mass spectra was indicated by the variations in relative position of lines which was greater than the error of measurement.

* Now a Fellow of the Institute of Radiobiology and Biophysics, University of Chicago.
[1] A. J. Dempster, Phys. Rev. 53, 64 and 869 (1938).

**B5. Radioactive Selenium 73 and 75.** WILLIAM S. COWART AND M. L. POOL, *Ohio State University.*—Germanium was bombarded with 20 Mev $\alpha$-particles and the arsenic and selenium fractions were removed by chemical separations. A new activity of 7.0 hours half-life was found in the selenium fraction. The emission was found to consist of 1.29-Mev positrons (0.59 gm/cm$^2$ Al) and a small amount of x-rays which had a wave-length of about 1.2A. $K$-electron capture is thus evident in this short positron period. Gamma-rays if present were very weak compared to the annihilation radiation. Since the activity is not produced by deuteron bombardment of As or Se, the assignment is made to $Se^{73}$. The decay is into a long period, presumably the 90-day period of $As^{73}$. No evidence of decay into the 2.08-day period of $As^{73}$ was found. Alpha-particle bombardment of Ge and deuteron bombardment of As give a long period activity in $Se^{75}$. Based upon nearly three years of decay a value of $127\pm2$ days was found. Decay is by $K$-electron capture.

**B6. Threshold for Proton-Neutron Reaction in Copper.** W. E. SHOUPP, B. JENNINGS, AND W. JONES, *Westinghouse Research Laboratories.*—The threshold energy for the production of neutrons from the bombardment of copper

with protons has been measured with a $BF_3$ chamber surrounded with paraffin as a neutron detector. The proton energy was calibrated against the $Li^7(p,n)$ reaction previously reported. The $(p,n)$ threshold occurs at $E_t = 2.405$ Mev giving $Q = -2.131 \pm .01$ Mev, and is evidently associated with the copper isotope $Cu^{65}$. This gives for the mass difference, $(Zn^{65} - Cu^{65}) = 1.376$ Mev. Using 64.995 m$\mu$ for the mass of $Cu^{65}$, the mass of $Zn^{65}$ is 64.9565 m$\mu$. Since the $Zn^{65}$ decays by positron emission, the maximum energy of the positron spectrum may be computed to be 0.355 Mev.

**B7. The Electro-disintegration of $Cu^{63}$, $Ag^{107}$, and $Ag^{109}$.** J. S. LAUGHLIN, L. S. SKAGGS, A. O. HANSON, AND J. J. ORLIN, *Urbana, Illinois.*—The external electron beam from the University of Illinois betatron has been used to study the electro-disintegration of $Cu^{63}$, $Ag^{107}$, and $Ag^{109}$ with electrons of energies 13 Mev, 16 Mev, and 17½ Mev. Sets of thin, uniform foils were inserted in the electron beam and the activities induced by the concommittant electro- and photo-disintegration reactions measured. The intercept in the first foil of the linear increase of activity as a function of foil position represents the electro-disintegration effect plus a small, known background x-ray effect. The electron current was measured by placing an open air ionization chamber just behind the foils which collected the ionization produced by the electrons which passed through the foils. The cross sections for the $(e; n, e')$ reaction at 16 Mev were determined to be 17, 49, and $77 \times 10^{-29}$ cm² for $Cu^{63}$, $Ag^{107}$, and $Ag^{109}$, respectively. The slope of the activity curves together with the theoretical value of the radiation cross section and the x-ray spectrum were used to estimate the photo-disintegration cross sections. These were consistently 400 times greater than those for electro-disintegration.

**B8. Technique of Producing an External Beam of Electrons from the Betatron.** L. S. SKAGGS, J. S. LAUGHLIN, AND L. H. LANZL, *Urbana, Illinois.*—The beam is removed from the University of Illinois betatron, using a magnetic shunt of laminated iron mounted inside a specially designed donut.[1] The mounting allows considerable motion of the shunt with respect to the donut. The electron orbit is sensitive to the position, size and shape of the magnetic shunt; too close proximity to the equilibrium orbit or too great a height causes automatic expansion of the orbit before the electrons have reached their maximum energy. A standard injector is used with its entire structure at a greater radius than that of the entrance end of the magnetic shunt. The perturbation of the magnetic field due to the shunt is removed at the time of injection by firing a 12 microsecond saw tooth pulse through a degaussing coil which surrounds the shunt. The beam emerges from the donut through a 1.5 mil duralumin window and has a width of about 0.7 cm and a height of 0.2 cm. The duration of the pulse of mono-energetic electrons is less than one microsecond and the energy can be continuously varied. The current is of the order of $10^{-8}$ amperes.

[1] L. S. Skaggs, G. M. Almy, D. W. Kerst and L. H. Lanzl, Phys. Rev. **70**, 95 (1946).

**B9. Search for Weak Natural Radioactivities by the Method of Active Daughter Extraction.** TRUMAN P. KOHMAN, *University of Chicago.*—It has been suggested[1] that some of the apparently stable nuclides of even mass number which lie near the stability limits may actually be beta-labile with very long lifetimes. The immediate decay products would be relatively short-lived radionuclides, which by chemical extraction would be extremely sensitive indicators for the activity of the parents. $Ca^{48}$ appears to be well outside the zone of stability.[2] A test for the presence of 44-hour $Sc^{48}$ in 3 kg calcium gave negative results, indicating a minimum half-life for $Ca^{48}$ of $5 \times 10^{15}$ years. $Sn^{115}$ seems definitely outside the stability zone for odd mass numbers. $In^{115}$ has a 4.5-hour metastable state, to which $Sn^{115}$ should decay if the $Sn^{115} - In^{115}$ mass difference exceeds the $In^{115*}$ excitation energy, 0.338 Mev. A search for $In^{115*}$ in 1.2 kg tin showed no activity, indicating a minimum half-life for this mode of decay of $Sn^{115}$ of $5 \times 10^{14}$ years. Since $Sn^{115}$ and $In^{115*}$ have the same spin, this sets an upper limit to the $Sn^{115} - In^{115}$ mass difference at 0.34 Mev.

[1] T. P. Kohman, "The limits of beta-stability," Phys. Rev. (to be published).
[2] See also I. Joliot-Curie, J. de phys. et rad. [8] **6**, 209 (1945), and Saha and Saha, Nature **158**, 6 (1946).

**B10. Performance of an Electron Multiplier Tube Counting Alpha Particles.** S. K. ALLISON AND L. DEL ROSARIO, *University of Chicago.*—Alpha particles from polonium were slowed down in air and admitted to an electrostatic deflector which selected energies (homogeneous to ~1 percent) in the range between 0.4 and 1.6 Mev. The particles were then detected by an electron multiplier tube of the type developed by J. S. Allen, having 12 beryllium copper electrodes. The pulses put out by the tube were electronically amplified in voltage by factors of 273, 546, and 1082 in various trials, and scaled and counted on conventional equipment. The combination of the tube and the relatively low external amplification constitutes a very reliable and stable detector of the presence of alpha particles; for instance, when counting 1150 particles per minute the background, with the polonium screened off, would be 20 per minute. The distribution of pulse heights is fully developed at 500 volts per stage in the tube. At a pressure of $4 \times 10^{-5}$ mm, half the alpha pulses put out by the tube were less than 0.03 volts in height and half above this value. A corresponding point in pulses from electrons whose energies were not accurately known but must have been less than 34 kev occurred at 0.005 volts, and if pulses less than 0.04 volts were discriminated against, the equipment responded only to alphas in the presence of betas. It is possible that at lower pressures than ours, the alpha pulse height distribution might be different.

MONDAY AFTERNOON AT 2:15

Judd Lecture Hall

(W. JAMES LYONS presiding)

## *Invited Papers of the Division of High-Polymer Physics*

**X1. A Theory of Commercial Yarn Testing.** CHARLES J. GEYER, JR.,* C. H. REICHARDT,** AND GEORGE HALSEY,** *Textile Foundation.*—A method has been devised for the application of the theory of the three-element shear model of Eyring and co-workers to textiles which does not necessitate the location of the "basic spring line" and thus is readily applicable to both yarn and fiber tests and to the commercial inclined-plane and pendulum-type testers. It is also applicable as a first approximation to those textiles which do not possess a "basic spring line" as such. The method employs the conventional spring constants or elastic moduli but determination of the viscous constant involves the magnitude of the relaxation in constant rate of elongation experiments (or the magnitude of the creep in constant rate of loading experiments) from the upper envelope per interval of time. The relationship has been employed to establish the correlation between the visco-elastic properties of "slashed" and "unslashed" viscose tire cord rayon yarns and also to show the identity of single filament stress-strain relationships with those of yarns of normal twist of the same textile. The simplicity of technique which enables this method to be used as a routine laboratory test for the determination of the visco-elastic properties of textiles affords it a distinct advantage over previous methods, which were often unsatisfactory from both a theoretical and an experimental viewpoint.

* American Viscose Corporation, Front Royal, Virginia.
** Fellows, The Textile Foundation.

**X2. Creep, Recovery, and Permanent Set for GR-S and Hevea.** S. D. GEHMAN, *Goodyear Tire and Rubber Company.*—In all of the tests with Hevea and GR-S, a considerable part of the creep was due to permanent set. The proportion increases with the elongation and duration of the test. At low elongations, GR-S shows much more creep than Hevea but a smaller portion of it is due to permanent set. At the start of the creep test, the flow appears to be due largely to the reversible yielding of relatively weak bonds which can reform under the action of the elestic network when the load is removed. For longer periods of time or for higher elongations, the flow involves more deep-seated changes in structure. Larger units of structure are displaced or stronger bonds broken with resultant permanent molecular displacements upon removal of the load. For Hevea at high elongations it is probable that flow occurs in the amorphous material between the crystallites with whole crystallites being displaced with reference to each other. Under such circumstances, the original relative molecular configurations cannot be reassumed upon removal of the load. Correction of the creep curves for permanent set gives nearly straight lines on a plot against logarithmic time.

**X3. The Thermodynamics of a Strained Elastomer. I. General Analysis.** M. MOONEY, *United States Rubber Company.*—The thermodynamic functions of principal interest in a strained elastomer are the entropy and energy of deformation. The volume is of secondary importance, and it can be assumed, with sufficient accuracy for most purposes, that the volume is linear in the temperature and the mean pressure. The basic partial differential equations of thermodynamics can then be integrated, yielding expressions for the energy and entropy of deformation in terms of observable quantities. In the present analysis the volume effects due to changes in mean pressure and crystallinity are taken into account; the effects associated with change in shape are sharply separated from those associated with change in volume. It is shown that the superelastic functions of deformation previously published* have a very general validity.

* M. Mooney, J. App. Phys. 11, 582 (1940).

**X4. The Thermodynamics of a Strained Elastomer. III. The Thermal Coefficient of Modulus and the Statistical Theory of Elasticity.** L. E. COPELAND AND M. MOONEY, *United States Rubber Company.*—Published thermoelasticity data are critically analyzed by means of thermodynamic equations developed in the first paper of this series. Equations known to be of the proper form are fitted by least squares to the experimental data, which were first corrected to allow for the changes in shape when tested under variable temperature and constant volume. If the measurements are accepted as truly reversible, the data show that several different elastomers depart considerably in some respects from the predictions of the statistical theory of elasticity. Some thermoelasticity measurements in torsion are reported which seem to give the most reliable evidence that stress is proportional to absolute temperature.

**X5. The Effects of Pile Bombardment on Uncured Elastomers.*** W. L. DAVIDSON, *Clinton National Laboratory and B. F. Goodrich Company,* AND I. G. GEIB, *B. F. Goodrich Company.*—Previous work on the effects of ionizing radiations on hydrocarbons has established that four competitive processes are usually operative: (1) Dehydrogenation, (2) condensation or polymerization, (3) hydrogenation (action of nascent hydrogen on any unsaturated matter present), (4) decomposition (C–C cleavage). The chain reacting nuclear pile offers an ideal means for subjecting relatively thick samples of matter (such as rubber) to uniformly high concentrations of radiation. Such studies on natural rubber, butyl rubber, and polyisobutylene allow one to draw the following

conclusions: (1) Uncured natural rubber undergoes a slight curing action when exposed to pile radiations. (2) Polyisobutylene samples are appreciably degraded by pile radiations. (3) The same effects as noted in (1) and (2) are greatly enhanced by secondary alpha-particles, produced by an $(n, \alpha)$ reaction on boron$^{10}$ (milled into the elastomer). However even a 2-hour bombardment of natural rubber yields a product greatly inferior to sulfur vulcanizates. (4) Pile bombardment does not introduce measurable unsaturation in polyisobutylene and decreases the unsaturation in natural rubber but slightly. (5) A typical butyl rubber stock is permanently degraded by pile irradiation showing upon cure reduced tensile strength compared to that of a control sample. (6) Natural rubber shows a weak but measurable radioactivity days after bombardment, probably because of its mineral content. polyisobutylene is not appreciably active.

* Part of the experimental work for this report was performed for the Atomic Energy Commission while Dr. W. L. Davidson was a member of the Clinton Laboratories Training School on leave from the B. F. Goodrich Company.

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## Tuesday Morning at 9:00

Judd Lecture Hall

(L. A. Wood presiding)

### *Joint Symposium of the High-Polymer Division and of Section B of the AAAS*

**Y1. The Hydrolysis of Proteins.** H. B. Bull, *Northwestern University.*

**Y2. Proteins as Polycondensations of Amino Acids.** Dorothy Wrinch, *Smith College.*—The native proteins are polycondensations of $\alpha$-amino acids, $NH_2-CHR-COOH$, in *levo* form, about 21 different species and 2 cyclic amino acids being recorded to date. The proteins are of unknown structure and the question then arises as to the light, if any, which polycondensations of known structure can throw upon this problem. The similarities and dissimilarities of proteins in particular and high molecular weight substances in general are discussed. The latter, several of which belong to the domain of crystal physics, are far more striking. They include the perfection of regularity of atomic arrangement attained by protein crystals and the high prevalence of twinning. The implications of the fact include the following. (1) While high molecular weight substances in general are "open" structures, whether they be chains (with or without branches or cross bonds) or 2- or 3-dimensional networks, the molecules of protein are "closed." (2) Some or all of the monomers in proteins have functionality higher than 2. Possibilities regarding this higher functionality are investigated. The further implications for the structure of proteins of the facts assembled are discussed, particularly in existence of protein twins, which leads to a new theory of twinning.

**Y3. Studies of the Melting Points, Rigidities, and Optical Activities of Gelatin Gels.** John D. Ferry and John E. Eldridge, *University of Wisconsin.*—Four ossein gelatin samples, previously degraded to varying extents to give number-average molecular weights ranging from 17,000 to 45,000, have been studied in solution in 0.15 M NaCl at pH 7. Gels were formed by chilling solutions at 0° for 24 hours and then subjected to the following measurements: (1) melting point as a function of gelatin concentration and degree of degradation, (2) rigidity as a function of temperature and degree of degradation, (3) optical activity as a function of temperature and degree of degradation. The melting point data gave a series of straight lines, one for each sample, when the logarithm of the concentration was plotted against the reciprocal of the absolute temperature of melting; the slopes were identical. With increasing temperature, the gel rigidity approached zero while the optical activity decreased to a constant value which was independent of molecular weight. In every case, the rigidity disappeared at a lower temperature than that at which the optical activity attained its minimum value. At a given temperature below the melting point, both rigidity and optical activity increased with increasing molecular weight. The gelation process is regarded as the formation of a three-dimensional network due to the gradual cross-linking of gelatin molecules at rather widely separated points. The optical activity curves indicate that some of these cross-links exist above the melting point but disappear above 40°C.

**Y4. Viscosity and Streaming Birefringence of Nucleic Acid.** Jesse P. Greenstein, *National Institute of Health.*—Aqueous solutions of the tetrasodium salt of thymus nucleic acid show anomolous viscosity and intense birefringence of flow. The compound behaves monodisperse in the ultracentrifuge and an $S=11$ has been calculated for a highly polymerized sample tested. When such solutions are irradiated by ultraviolet light (2537A) or by x-rays, these properties are considerably diminished at a rate which is roughly proportional to the amount of radiation administered. On cessation of ultraviolet irradiation, the reduced value for the viscosity remains constant. On cessation of x-irradiation, the reduced value for the viscosity diminishes further with time of standing. There are thus two consecutive phenomena as a result of x-irradi-

ation, that which occurs during irradiation and which has no apparent temperature coefficient, and that which occurs after irradiation has ceased, and which is dependent upon the temperature. The average S for the particles of nucleic acid after x-irradiation is about 5. Such particles do not pass through cellophane. No ammonia or phosphate is released. A similar reduction in viscosity and birefringence occurs in nucleic acid solutions treated with various salts, and with proteins.

**Y5. The Study of Macromolecular Reactions of Biological Interest.** PAUL DOTY, *Notre Dame University.*

## TUESDAY MORNING AT 10:00

## Oriental Institute

## (J. R. OPPENHEIMER presiding)

**C1. On the Neutral Meson.** R. E. MARSHAK, *University of Rochester.*—It is proposed to accept the hypothesis of Anderson *et al*, that the light meson decays into an electron and a neutral meson of mass 70 Mev, and to identify this neutral meson with the unobserved particle accompanying the light meson in the disintegration of the heavy meson. This identification has the following three consequences: the mass of the heavy meson is 180 Mev (which is within the experimental error of the British measurements), the spin of the heavy meson is $1/2\hbar$ (independent of the spins of the light and neutral mesons), and the capture of light negative mesons by heavy nuclei can still be explained in terms of the virtual creation of negative heavy mesons directly coupled to nucleons (since the mass difference between the light meson and the neutral meson is 30 Mev). If, further, the neutral meson is assumed to be directly coupled to the nucleon, and to possess a spin of zero, it follows that the capture of a negative light meson by a nucleus should be accompanied by the emission of two light quanta, each with an energy of 35 Mev and that neutral mesons should be produced with appreciable cross section by the new high energy accelerators.

**C2. Sea Level Latitude Effect of Cosmic Radiation.*** PETER A. MORRIS, W. F. G. SWANN, AND H. C. TAYLOR, *Bartol Research Foundation.*—On a recent voyage from Rio de Janeiro to Boston the vertical intensity of the total and hard components of the cosmic radiation were measured with a Geiger-counter telescope apparatus, with the following results:

Percentage diminution in the vertical intensity.

| Telescope | Total Radiation No Lead | Hard Component 8 cm | Hard Component 16 cm | Soft Component 8 cm diff. | Soft Component 16 cm diff. |
|---|---|---|---|---|---|
| 1 and 2 | 5.05±0.55 | 5.26±1.27 | 5.36±1.33 | 4.3±4.6 | 4.5±4.3 |
| 1 | 5.34±0.77 | 4.96±0.92 | 6.20±0.97 | 6.0±2.8 | 3.7±2.9 |
| 2 | 4.76±0.75 | 5.56±0.88 | 4.51±0.91 | 2.6±3.7 | 5.3±3.2 |
| Combined | | 5.32±0.46 | | 4.46±0.61 | |

Careful consideration has been given to the probable errors as derived from statistical analysis, and the results are interesting as indicating, more reliably than heretofore, a latitude effect for the soft component comparable with that for the hard component.

* Supported by funds from the Navy and from the National Geographic Society; also by airplane services from the U. S. Army Air Force.

**C3. High Energy Atmospheric Showers.*** HENRY L. KRAYBILL, *University of Chicago.* (*Introduced by Marcel Schein.*)—The altitude dependence of high energy atmospheric showers in the cosmic radiation was measured between 30,000 and 40,000 feet pressure altitude in a B-29 airplane. The counting rate of counters in 3-fold coincidence was determined for horizontal counter separations of 9 feet, 13.5 feet, and 42 feet. The counting rate of the counters separated by 13.5 feet was found to be equal to the rate of counters separated by 9 feet. The counting rate of counters with separation of 42 feet was 0.6 of the rate of counters with spread of 9 feet. The counting rate of both the large and the small separations decreased with altitude above 30,000 feet. Near 40,000 feet the combined counting rate of the counters with separation of 9 feet and 13.5 feet was approximately two-thirds of their rate at 30,000. These results, together with previously reported measurements[1] between 15,000 feet and 33,000 feet, show the existence of a maximum in the frequency *versus* altitude curve of high energy atmospheric showers at an elevation near 30,000 feet.

* The research described in this abstract was supported in part by U. S. Navy.

[1] Henry L. Kraybill and Paul J. Ovrebo, Phys. Rev. **72**, 351 (1947).

**C4. The Mean Life of Negative Mesotrons.*** HAROLD K. TICHO, *University of Chicago.*—The fact that negative mesotrons stopped in materials of low atomic number do disintegrate has been explained as resulting from comparable probabilities for disintegration and capture by the nuclei of the absorber. If this explanation is valid, a change of the mean life of negative mesotrons should occur.[1] To establish this effect experimentally, and to determine whether it has any bearing on the recent result for the mean life obtained at Climax,[2] a magnetic lens and a special timing circuit were used such that the mean

lives of positive and negative mesotrons could be determined separately. The precision of this device will be discussed.

* The research described in this abstract was supported in part by U. S. Navy.
[1] Harold K. Ticho and Marcel Schein, Phys. Rev. **72**, 248 (1947).
[2] Harold K. Ticho, Phys. Rev. **72**, 255 (1947).

**C5. The East-West Asymmetry of the Mesotron Component at 35,000 Feet.*** VICTOR H. YNGVE, MARCEL SCHEIN, AND HENRY L. KRAYBILL, *University of Chicago.*—The East-West asymmetry of mesotrons passing through 22 cm of lead was measured in a B-29 airplane at altitudes between 30,000 feet and 40,000 feet. At 27° north magnetic latitude and at an elevation of 35,000 feet the asymmetry at a 45° zenith angle was found to be 45 percent. This very large asymmetry is close to the predicted theoretical value, assuming that the primaries in the energy range covered by the experiment are all positively charged. The predicted value is obtained from the observed latitude effect and the theory of Lemaitre and Vallarta. Since a large fraction of the primaries are included within the energy range covered by this experiment, it is obvious that the mesotron-producing component of the cosmic radiation predominantly consists of primary protons.

* The research described in this abstract was supported in part by U. S. Navy.

**C6. Burst Production at an Altitude of 11,200 Feet.*** E. F. FAHY AND MARCEL SCHEIN, *University of Chicago.*—The frequency of large cosmic-ray bursts were detected in coincidence with extensive atmospheric showers registered by four independent counter coincidence sets spread over the chamber in a horizontal plane. The chamber, which was filled with 50 atmospheres of pure argon, was first surrounded by 7.7 cm of lead and later by 12 cm of lead. Only a few percent of the large bursts under the lead were accompanied by extensive atmospheric showers at an altitude of 11,200 feet (Climax, Colorado). Since these bursts are very absorbable in the atmosphere between 11,200 feet and sea level, it is suggested that they should originate from the disintegration of mesotrons with a lifetime shorter than $10^{-6}$ second.

* The research described by this abstract was supported in part by U. S. Navy.

**C7. Calculations on the Mesotron Distribution at the Geomagnetic Equator.*** J. STEINBERGER AND MARCEL SCHEIN, *University of Chicago.*—The energy spectrum at sea level and the intensity *versus* altitude curve were calculated for mesotrons at the geomagnetic equator. The assumptions were similar to those made in a previous calculation by the authors.[1] The energy spectrum at sea level is in rough agreement with the experimental data; however, the maximum occurs at energies higher than the one measured by J. G. Wilson.[2] This could actually be due to a production of low energy mesotrons in the lower part of the atmosphere.

* The research described in this abstract was supported in part by U. S. Navy.
[1] Marcel Schein and J. Steinberger, Phys. Rev. **72**, 734 (1947).
[2] J. G. Wilson, Nature **158**, 414 (1946).

**C8. The Absorption Curve of Mesotrons On Mount McKinley, Alaska.*** MARCEL SCHEIN AND THOMAS H. CARR, *University of Chicago.*—The penetration of mesotrons was measured through thicknesses of 10, 20, 30, 40, and 50 cm of lead at an elevation of 18,200 feet above sea level. Special precautions were applied to minimize the effect of scattering in the lead. The data show that a large number of mesotrons is present between energies of $1.5\times10^8$ ev and $7\times10^8$ ev at this altitude. Using the measured energy spectrum on Mount McKinley, the diffusion of mesotrons was calculated between the elevations of 18,200 feet and 14,250 feet (Mt. Evans, Colorado). The results show that at 14,250 feet the theoretical number of mesotrons between $10^8$ ev and $4\times10^8$ ev is considerably smaller than that actually found by experiment.[1] This fact strongly indicates that a secondary production of slow mesotrons exists in the lower part of our atmosphere.

* The research described in this abstract was supported in part by U. S. Navy.
[1] David B. Hall, Phys. Rev. **66**, 321 (1944).

**C9. Mesotrons in the Stratosphere.*** MARCEL SCHEIN, *University of Chicago.*—A discussion will be given of recent results on the intensity and on the production of mesotrons. These results were obtained in the high atmosphere in airplanes and balloons. In particular, the problem will be considered whether mesotrons of energies lower than $4\times10^8$ ev are produced in the primary act of mesotron creation.

* The research described in this abstract was supported in part by U. S. Navy.

**C10. Periodic Variation of Ground Level Count of Cosmic-Ray Air Showers.** PAUL J. OVREBO, *Aircraft Radiation Laboratory.*—Observations, with triple coincidence counters, of high energy atmospheric showers in the cosmic radiation have been made at ground level for a six month period between April 16 and October 16, 1947. The daily counting rate is found to undergo variation in a periodic fashion. A Cree analysis of the data suggests a period of 22 days. Assuming sine type of variation, different periods were fitted to the data by method of least squares. A maximum amplitude of 9.7 percent of the daily average count was found for a period of 21.5 days. The daily average count for the six months is 17.08. Comparison with the daily Zurich sun spot number showed no obvious correlation. No study of the relation with meteorological phenomena has as yet been made.

**C11. On the Insensitive and Recovery Times of Self-Quenching Counters.** S. S. FRIEDLAND, *Memorial Hospital and New York University* AND A. D. KRUMBEIN, *New York University.*—An investigation of the insensitive times and recovery times of self-quenching Geiger-Müller counters, using the method described by Stever, has been undertaken. Various quenching mixtures have been studied. The percentage of the quenching molecule present as well as the total pressure was varied to study their effects on the values obtained. Attempts will be made to correlate these data with existing theories.

**C12. Pulse Shape of Self-quenching Counters.** C. D. THOMAS, *West Virginia University.*—An investigation of the shape of the pulse decay from a self-quenching counter has been carried out under the condition that the time constant of the circuit, including capacity in addition to that of the tube, is not negligible in comparison to the transit time in the tube. The resulting mathematical expression yields the voltage on the wire as a function of time and of physical constants of the counter and the circuit. In addition to the exponential decay, this formula contains product terms of it with an exponential integral and a term varying inversely with time. By varying conditions it is possible to approximate either pure self-quenching or external quenching. Some data obtained by photographing pulses from counters using different circuit constants has been studied and compared to the predicted form.

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## TUESDAY MORNING AT 10:00

## Eckhart Hall, Room 113

## (L. A. DUBRIDGE presiding)

**D1. A Two-Dimensional Potential Problem with Application to Soil Drainage.** DON KIRKHAM, *Iowa State College.*—A thin sheet of conducting material, surface conductivity $\gamma$, infinitely long, and of width $H$, rests coplanarly on rectilinear legs of the same material of width $a$, ($a \ll 2H$), height $h$, ($h \gtrsim a/2$), and equal spacing, $A$. On the longitudinal center line and at a distance $h-d$ from the base of each leg is located a circular electrode of radius $r$, ($r \lesssim a/4$). Utilizing former results,[1] the potential and flow are calculated when the uppermost surface is at potential $V$, the electrode zero. If $A > 2H$, the current per electrode $I$ is approximately (an upper limit)

$$I = 2\pi\gamma V / 1n \cot^2 \frac{\pi a}{8H} \cdot \frac{\sinh \pi(2d-r)/a}{\sinh \pi r/a} \cdot \frac{\sinh^2 \pi h/a - \sinh^2 \pi r/a}{\sinh^2 2\pi h/a - \sinh^2 \pi(2d-r)/a},$$

a result independent of $A$, also valid when the electrodes rest on the bases of the legs. This problem arises in the analogous groundwater case, that of seepage from waterlogged soil into long drainage tubes installed in trenches cut into an impervious substratum underlying a pervious upper layer, the trenches being back-filled with the pervious soil.

[1] D. Kirkham, Proc. Soil Sci. Soc. Am. (1947).

**D2. The Cesium Rectifier.** A. W. HULL, E. E. BURGER, AND R. E. TURRENTINE, *General Electric Research Laboratory.*—This is a new type of hot-cathode vapor rectifier, in which cesium vapor functions both as conducting gas and thermionic coating material. The cathode is of the familiar type used in thyratrons, namely, a multivane structure of nickel vanes, surrounded by a heat-shield. However, the vanes are uncoated except by the monatomic film of cesium which is reformed continually by condensation. The tube must be heated to approximately 150°C during operation, to maintain the desired vapor pressure of 0.01 mm. Cesium is unique in having the lowest ionization potential and the lowest thermionic work function of any known substance. Hence one would expect optimum efficiency from this dual use of cesium. This expectation appears to be realized, the over-all efficiency at 250 volts being better than 98 percent for the experimental tubes tested. Typical values are: cathode heating power, 200 watts; peak electron emission, 2000 amperes; voltage drop at 600 amperes, 3 volts.

**D3. Response of a Linear System to an Input with Uniformly Increasing Frequency.** H. EKSTEIN, *Armour Research Foundation.*—This problem, or rather its mechanical analog, was previously solved exactly for the case of an L–C–R circuit by F. M. Lewis.* His method is too cumbersome for more general systems. An approximate solution, for slow frequency modulation, expressible in terms of elementary functions, is given. The problem reduces to the evaluation of the integral

$$I = \int_{-\infty}^{\infty} Y(p) \exp\left[-\frac{i(p-\omega)^2}{2\beta}\right] dp,$$

where $Y$ is the admittance of the system, $\beta = \Delta\omega/\Delta T$ the rate of increase of the angular frequency, and $\omega$ the instantaneous angular frequency. The method of evaluation used is the saddle-point method (method of steepest descent). Features of the calculated response curve are:

1. The maxima of the response curve lag behind those of the quasi-stationary curve.
2. The maxima are lowered with respect to the quasi-stationary case.
3. At certain frequencies a damped oscillation appears (ringing).

The lag, the depression of the maximum, and the frequency at which "ringing" appears can be calculated in a simple manner although only approximately.

* F. M. Lewis, Trans. A.S.M.E. **54**, 253 (1932).

**D4. Transit Time of Electrons between Electrodes of Simple Geometry.** DELBERT N. EGGENBERGER AND PAUL L. COPELAND, *Illinois Institute of Technology.*—In simple cases the transit of an electron starting from rest is proportional to the length of path and inversely proportional

to the square root of the potential difference through which the electron falls. The dependence of the proportionality factor on the geometry and on the current density has been treated mathematically in those cases for which a simple symmetry exists. In the absence of space charge the transit time is computed directly by the aid of the known potential distribution and the energy equation. Where space charge exists, the definition for current density, Poisson's equation, and the energy equation are combined to give an expression for the transit time of electrons. This expression has been evaluated for complete space charge by the use of the solutions for current as a function of potential difference which have been developed by Langmuir and Blodgett[1] and by Page and Adams.[2] Approximations have been made to give the transit time as a function of current density.

[1] Langmuir and Blodgett, Phys. Rev. **24**, 49 (1924).
[2] Page and Adams, Phys. Rev. **68**, 126 (1945).

**D5. Further Study on Direct Coupled Pentode and Decade Rings.** LEO SEREN AND LAWRENCE JONES, *General Electric Research Laboratory.*—Pentode pairs, in which the plate of one pentode is tied to the screen grid of another, and *vice versa*, have been studied further.[1,2] Such a pair has two distinct states of equilibrium and is used in scalers, electronic switches, etc.[3] Topics that will be discussed include: (1) stability of the pair for different plate resistors, plate supply voltages, and grid bias voltages; (2) triggering adjacent pentode pairs by means of triodes; (3) shape and size of pulse for triode triggering; (4) resolution of the triggering action for closely spaced input pulses; (5) power requirements. One result of this study has been a decade ring which has a resolution better by a factor of two than that reported in the past for direct coupled pentode pairs.[2] Using 6AK6 pentode pairs with 21,000-ohm plate resistors a decade ring has been built which resolves any two pulses as close as 0.9 microsecond and three pulses as close as 2.0 microseconds.

[1] V. H. Regener, Rev. Sci. Inst. **17**, 180 (1946).
[2] Leo Seren, Rev. Sci. Inst. **18**, 654 (1947).
[3] V. H. Regener, Rev. Sci. Inst. **17**, 185, 375 (1946); also see reference 2.

**D6. An Electronic Analogy Computer for Studying Servomechanism Response.** M. SHEPHERD, JR.,[1] J. H. BALDWIN,[2] AND G. H. FETT, *University of Illinois.*—A servomechanism analogy computer has been developed which utilizes electronic circuits to represent the actual components. All system elements have been reduced to equivalent resistors and capacitors together with appropriate mixing and feed-back circuits. The computer has all constants of the system referred to a new time base so that the transients developed in the system can be observed visually on a cathode-ray oscilloscope. A force function of either step displacement or step velocity is impressed at a frequency of 20 cycles per second, and the transient is viewed for about 0.01 second, and the remainder of the time is utilized to restore the system to equilibrium. A detailed example of a servomechanism is given, in which an amplifier controls the field current of a d-c generator which supplies power to a separately excited d-c motor. The counter e.m.f. of the motor is arranged for by an appropriate feed-back and mixing link between the motor load analogy and the armature input circuit analogy. Both stable and unstable servomechanism arrangements can be examined with this computer. The effect of changing circuit parameters is easily noted by the change in oscillograph pattern.

[1] At present with Farnsworth Radio and Television Corporation.
[2] Westinghouse Educational Fellow, University of Illinois, 1947; at present with Electronic Laboratories of Canada, Ltd., Vancouver, B.C.

**D7. Shaped Field for 180° Spectrograph.** F. M. BEIDUK AND E. J. KONOPINSKI, *Indiana University.*—A 180° spectrograph built recently by L. M. Langer employs the magnetic field between two annular ring pole faces. This construction permits a shaping of the radial dependence which causes perfect focusing of the electrons diverging from a point source on the main circle and moving in the median plane between the poles. The condition for this may be expressed by

$$\int_0^{\delta_0} \frac{(f+\gamma)d\delta}{(1+\delta)[(1+\delta)^2-(f+\gamma)^2]^{\frac{1}{2}}} = \frac{\pi}{2}. \tag{1}$$

$\delta$ is the radial distance from the main circle in units of its radius; $\gamma$ is the direction cosine of the emerging electron; $\delta_0$ is the root of the radical in the integrand; $f$ is the vector potential multiplied with the distance from the center in proper units. A solution in power series gives the result for the magnetic field:

$$H = H_0\left[1-\frac{3}{4}\delta^2+\frac{7}{8}\delta^3-\frac{9}{16}\delta^4+\frac{35}{256}\delta^5\cdots\right]. \tag{2}$$

**D8. Force between Magnets in a Medium.** JOHN A. ELDRIDGE, *State University of Iowa.*—The force between magnetic poles in a medium is usually given as $F = m_1m_2/\mu r^2$. This follows from the relations $\mathbf{B} = \mathbf{r}_0 m/r^2$ (where $\mathbf{r}_0$ is a unit vector) and $\mathbf{F} = m\mathbf{H}$. Several writers (Wilberforce, Page, Adams, Murdock) have remarked that these relations are incorrect. To obtain a correct relation *magnetic pole* must be exactly defined: Pole density $(\alpha) = -\text{div}.\mathbf{P}$, where $\mathbf{P}$ is the intensity of magnetization (magnetic polarization). It then follows that $\mathbf{H} = \int \mathbf{r}_0 \alpha d\tau/r^2$, or for large $r$ (where we can consider poles as points) $\mathbf{H} = \mathbf{r}_0 m/r^2$. It can also be shown that the force on a pole is given by $\mathbf{F} = \int \mathbf{B}\alpha d\tau$ or for a point pole $\mathbf{F} = \mathbf{B}m$. Since $\mathbf{B} = \mu\mathbf{H}$ the force between point poles becomes $F = m_1m_2\mu/r^2$, where $m_1$, $m_2$ are the poles actually existing, including the poles in the medium. The results show that the force between two ideal permanent magnetic shells is increased (not decreased) by the presence of a paramagnetic medium, exactly as for the force between currents. (Similar relations hold for ideal electrets.) More aptly the force between magnets can be regarded as a force between "apparent currents" $I_1$, $I_2$, where the apparent current density $\sigma$ is defined by $\sigma = \text{curl}.\mathbf{P}$. Here $\mathbf{B}$ (not $\mathbf{H}$) is obtained from $\mathbf{I}$ by the Biot-Savart law and $\mathbf{F} = \mathbf{I}\times\mathbf{H}dl$ (not $\mathbf{I}\times\mathbf{B}dl$).

**D9. The Magnetic Susceptibility of Uranium Oxalate.** C. A. HUTCHISON AND N. ELLIOTT, *University of Chicago.*—

Magnetic susceptibilities of tetravalent uranium compounds published in the literature may be interpreted as showing the $U^{4+}$ ion to be in a $^3F_2$ state. We have prepared the compound $U(C_2O_4)_2 \cdot 3H_2O$ and measured its susceptibility over the temperature range 78°–328°K. The Weiss-Curie law is obeyed in the range 240°–328°K, but deviation is found at the liquid nitrogen temperature. At the higher temperatures the Weiss constant has the value $\theta = +165°K$. The magnetic moment of the $U^{4+}$ ion is 3.66 Bohr magnetons, in good agreement with the value 3.62 calculated for a $^3H_4$ state, and provides evidence that the heavy elements are like the rare earths in electronic structure. The magnetic susceptibility of uranium oxalate as a function of temperature is similar in behavior to that of praesodimium sulphate octahydrate, and deviation from the Weiss-Curie law can be explained as due to the crystalline field around the $U^{4+}$ ion.

**D10. On the Width of r-f Absorption Lines in Solids.** J. H. VAN VLECK, *Harvard University.*—In crystals, the breadth of the absorption lines arising from nuclear magnetic moments is caused mainly by the "dipolar" or "magnetic" interaction between the different nuclear spins. The resultant line width is computed by calculating, by quantum mechanics, the mean-square deviation from the central Larmor frequency and assuming that the shape of the line is approximately Gaussian. The resulting line width agrees surprisingly well with measurements by Purcell and Bloembergen on $CaF_2$, including prediction on how the width depends on the angle between the applied constant field and the principal cubic axes. On the other hand, the absorption lines of many paramagnetic salts in the microwave region, arising from electronic spin, are often considerably narrower than the dipolar mechanism would predict. It is shown that this discrepancy is probably caused by exchange coupling between the spins. The exchange forces do not influence the mean square, but can greatly increase the mean fourth power of the frequency deviation. As a result the line is peaked more sharply in the center, and has a smaller half-breadth than otherwise. Since exchange integrals diminish rapidly with distance, this mechanism explains why the narrowing is found mainly in materials with a high concentration of paramagnetic ions.

**D11. Comparison of Detection Methods for Microwave Spectra.*** JOHN ROGERS, RICHARD J. WATTS, AND DUDLEY WILLIAMS, *Ohio State University.*—A report will be given on experimental results obtained with several methods for observing microwave absorption in the 1.25-cm region. The methods employed include: (1) single-crystal detection with a broad band audio-amplifier, (2) single-crystal detection with differentiation and with rejection filters for low frequencies, (3) single-crystal detection with double modulation of the Klystron reflector, and (4) single-crystal detection with several forms of Stark-effect modulation tubes. The relative advantages and limitations of these methods will be discussed in connection with results on ammonia, methanol, cyanogen bromide, and other gases.

* The work was done with aid from Watson Laboratories of the Army Air Forces Air Materiel Command and the Ohio State University Research Foundation.

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## TUESDAY AFTERNOON AT 2:00

### Oriental Institute

(M. A. TUVE presiding)

### *Joint Session of the AAAS, the AAPT, and the APS*

***Retiring Address of the Vice-President of Section B of the AAAS***

**The Physics of Radar.** L. A. DUBRIDGE, *California Institute of Technology.*

(J. H. VAN VLECK presiding)

### *Invited papers of the American Physical Society*

**Interactions between Elementary Particles.** E. FERMI, *University of Chicago.* (30 min.)

**Mass-Spectrographic Identification of Radioactive Isotopes.** A. J. DEMPSTER, *Argonne National Laboratory.* (20 min.)

**Neutron Polarization and Ferromagnetism.** D. J. HUGHES, *Argonne National Laboratory.* (30 min.)

TUESDAY AFTERNOON AT 2:00

Eckhart Hall, Room 113

(CYRIL S. SMITH presiding)

## *Invited Paper*

**Low-Temperature Transformations in Lithium and Some of Its Alloys.** C. S. BARRETT, *University of Chicago.* (30 min.)

## *Contributed Papers*

**E1. Fluctuations in Properties of Liquids and the Effect of Radiations on Them.*** GEORGE ANTONOFF, ALEXIS YAKIMAC, AND DUNCAN RANDALL, *New York University.*—In a paper given before this society on November 10, 1945, it was mentioned that two phases in equilibrium contain an equal number of molecules per unit volume. This means that a liquid must be associated to be in equilibrium with its vapor. X-ray analysis corroborates this view indicating the presence of loose aggregates. They assume a series of temporary positions so that one particle may get into an aggregate and get out and so on. The conditions of mobile equilibrium is attained when a large aggregate leaves the liquid, disintegrates into molecules thereby increasing pressure which compels molecules to go back into the liquid and join the aggregates. This theory was criticized in a private letter by Bridgman because such systems can have real existence only if they exhibit fluctuations which can be detected experimentally. I thus made experiments with alcohol, water, and aqueous solutions. Densities measured in a thermostat regulated within 0.002°C showed distinct fluctuation beginning with the 4th decimal. In some organic liquids there are fluctuations within 3 decimals which are affected by radiations. They ultimately stop. Water exhibits no fluctuations within three decimals, but in the fourth and following a zig-zag curve obtained is somewhat distorted by radiations, but fluctuations show no tendency to stop.

* This paper, mailed on September 30 and intended for the Houston meeting, was unluckily mislaid by the Secretary.

**E2. The Damping Capacity of Anodized Aluminum.** A. HAMMOND, J. MICHENER, J. KOEHLER, E. SALKOVITZ, *Carnegie Institute of Technology.**—The logarithmic decrements of single crystals and of polycrystals of aluminum were measured before and after the deposit of an oxide film. It was found that the damping increases by a factor of two if a film $10^{-4}$ cm thick is deposited. Since the specimens weigh two grams or more and the weight of the oxide is only five milligrams, it does not seem possible that this effect arises simply from a loading of the specimen. The measurements were made by gluing the rod-shaped specimens to piezo-electric quartz crystals. The damping was then determined by investigating the electrical behavior of this composite oscillator near its fundamental frequency using an a.c. bridge of the type described by T. A. Read.[1] All measurements were made at a frequency of 38.5 kilocycles and at a strain amplitude of $10^{-8}$. Two single crystals and two polycrystals were used and the specimens were anodized and then stripped of oxide twice. The decrements encountered ranged from 1 to $10\times10^{-5}$. The decrement measurements are good to $\pm10$ percent.

* This work was done under a contract with the Office of Naval Research.

[1] T. A. Read, Phys. Rev. **58**, 371 (1940).

**E3. Piezoelectrid Effect in Polycrystalline Barium Titanate.** WALTER L. CHERRY, JR., AND ROBERT ADLER, *Zenith Radio Corporation.*—Polycrystalline barium titanate is rendered piezoelectric by application of an electric field. After removal of the field the effect decreases, rapidly at first, then gradually, and stabilizes at about 0.85 of the initial level. The degree to which this material is made piezoelectric and its stability depend on the time of exposure and field intensity. Highly piezoelectric pieces of good stability are produced in a few minutes with field strengths of 20 kv/centimeter. Several hours are required at lower fields. The piezoelectric axis has the direction of the electric field used in forming. Subsequent application of an alternating field in this direction causes elongation and contraction. An alternating field, perpendicular to the direction of polarization, causes shear in the plane of the polarizing and alternating fields. The electromechanical coupling coefficient is about 0.40 for shear and 0.35 for longitudinal vibrations.

**E4. Rupture of Metal Foils under Constant Load.** WALLER GEORGE AND GEORGE IRWIN, *Naval Research Laboratory.*—The process of rupture of notched metal foils loaded in tension has been studied using microscope and high speed camera techniques with the object of extending Griffeth's[1] concept of critical crack length to fracturing of ductile metals. The majority of the measurements made used six-inch widths of commercial aluminum, lead, tin, zinc, and copper foils. The notch was a short, narrow cut in the center of the loaded section of the test sheet. The typical fracturing process consists of a slow elongation of the notch normal to the direction of the applied tensile load until a critical length is reached. The velocity of extension of the crack then increases rapidly and the rupture process is completed with a velocity as much as eight orders of magnitude larger than that at the beginning. A comparison of lengths for onset of rapid

fracturing with theory is given. The general usefulness of this simple experiment for studies of fracturing of metals is discussed.

[1] A. A. Griffeth, Trans. Roy. Soc. **A221**, 163 (1920).

**E5. Stress-Induced Interstitial Diffusion of Carbon and Oxygen Atoms in Tantalum.*** T'ING-SUI KÊ, *University of Chicago.*—Relaxation phenomena have been observed in tantalum specimens containing small amounts of carbon or oxygen. The internal friction peaks occur respectively around 150°C and 170°C for carbon and oxygen when the frequency of vibration is about one cycle per second. The activation energies associated with these relaxations were found to be 25,000 calories per mole for carbon and 30,000 calories per mole for oxygen. An analysis of the internal friction-temperature curves and a study of the thermal variation of the relaxation strength were made. These indicate that the observed relaxations are associated with the anelasticity caused by the stress induced preferential distributions of carbon or oxygen atoms among the three possible types of tetragonal interstitial positions in tantalum which has a body-centered cubic structure. The establishment of such preferential distributions can only be accomplished by the diffusion of carbon or oxygen atoms among these interstitial positions. Such a picture had been proposed by Snoek in interpreting the relaxation phenomena observed in alpha-iron (body-centered cubic) containing small amounts of carbon or nitrogen. The observations in tantalum thus indicate that such relaxations are characteristic of all interstitial solid solutions of body-centered cubic metals.

* This research has been supported by ONR.

**E6. Calculation of the Dielectric Constant of Tellurium.*** V. A. JOHNSON, *Purdue University.*—Scanlon and Lark-Horovitz[1] have recently investigated the electrical properties of tellurium. In order to compare their results with semiconductor theory, it is necessary to know the dielectric constant of tellurium. The value is estimated from optical constants by two different methods. The first method, developed by Mullaney,[2] uses the classical dispersion formula to obtain the dielectric constant from the index of refraction and coefficient of extinction. Since tellurium is non-isotropic, there are two sets of such data depending upon whether the single-crystal axis is parallel or perpendicular to the plane of incidence. For these two cases, the dielectric constant is found to be $5.0\pm0.5$ and $2.2\pm0.5$, respectively. For a tellurium sample composed of many randomly oriented crystals, the dielectric constant may be taken as an average. The second method uses reflectivity data and is based upon the electromagnetic theory of light in a conducting medium. This method yields a dielectric constant of 3.9 for tellurium. The second method, applied to reflectivity data for selenium, yields a dielectric constant in agreement with the observed values.

* This work was supported by Signal Corps contract.
[1] W. Scanlon and K. Lark-Horovitz, Physical Review **72**, 530 (1947).
[2] J. F. Mullaney, Physical Review **66**, 326 (1944).

**E7. Effect of Atmosphere on the Outgassing and Evaporation. Rates of Antimony.** R. L. LONGINI, *Westinghouse Research Laboratories.*—A practical limitation for the rate of outgassing metals such as antimony is set by the evaporation of the metal. When an inert gas is introduced during the outgassing process, the rate of both processes is determined by diffusion through the gas. On the basis of kinetic theory considerations it seemed plausible, however, that the evaporation would be slowed much more than the outgassing rate as one proceeds from straight evaporation to the diffusion mechanism. Consequently, it would be possible to speed the outgassing rate, for instance by raising the temperature, and still keep within the limit set by evaporation, if an inert gas were used. This was verified by direct weighings, on a microbalance, of a heated sample of antimony in a helium atmosphere. Results obtained checked well with theoretical expectations. The rate of evaporation was reduced to about two percent when introducing 0.01 atmosphere of helium, whereas the outgassing rate remained practically unaffected by helium at this pressure. A pressure of 0.10 atmosphere of helium was needed before the outgassing rate changed sufficiently to measure the decrease.

**E8. Bridge Values of $\beta$ for Non-Ohmic Disks.** S. BLOOMENTHAL, *Automatic Electric Company, Chicago.*—If the non-ohmic character of contacts between silicon carbide crystals originates in a thin layer of silica on each, then the ferrous oxide-silica reaction ought to affect the electrical characteristics. The bridge method of Baker* was used to obtain $\beta$ in the relation $E=CI^{\beta}$ applying to non-ohmic disks $0.75''\times0.05''$, consisting mainly of silicon carbide. $\beta$ has the average bridge values 0.26, 0.28, 0.31, 0.32, and 0.34 for heat treated disks pressed from mixtures containing 0, 2½, 5, 7½, and 10 percent powdered iron, respectively. The direct current at 53 volts was about one m.a. Values of $\beta$ from d.c. measurements were lower than those observed with the bridge. In view of the approximation used, some difference in results by the two methods is expected. An increased disparity was noted between $\beta$-values obtained by the two methods for disks from the batches containing appreciable additions of powdered iron. This is believed due to the enhanced temperature sensitivity of the current-voltage relation.

* Baker, Phil. Mag. **37**, 498 (1946).

**E9. Half-Dislocations.** W. SHOCKLEY, *Bell Telephone Laboratories.*—The stress fields of screw dislocations of the form $u=v=0$, $w=(b/2\pi)\tan^{-1}y/x$ have energies of interaction in an isotropic medium closely analogous to the field energy of two current-carrying wires. Two such dislocations, $R$ apart, have potential energy $(b_1b_2\mu/2\pi)\ln R$. Any dislocation can be resolved into two components for which the net displacement on a circuit about the dislocation is (1) perpendicular (Taylor-type) and (2) parallel (Burgers-screw type) to the dislocation axis. The force between two parallel dislocations does not involve cross terms of type (1), (2). These results are employed in analyzing the stability of a dislocation in the face-centered cubic lattice with a slip of $(a/2)(01\text{-}1)$ in the (111) plane

compared to two "half-dislocations" of $(a/6)(11\text{–}2)$ and $(a/6)(\text{–}12\text{–}1)$ which together produce the same net displacement across the (111) plane. It is found that the repulsive forces due to the Taylor-like component of these dislocations overcomes the attraction due to the screw components so that the half-dislocations tend to separate. A consideration of the nature of the "half-slipped" plane shows that it will be greatly hardened for slip on planes cutting through it and that this effect may play a major role in the hardening of unused slip planes.

**E10. Studies of the Glow Discharge in Mercury Vapor Contained in Cylindrical Tubes with Glass Walls.** B. PEARSON DELANY AND PAUL L. COPELAND, *Illinois Institute of Technology.*—The breakdown potential in the vapor between a mercury cathode and a nickel anode, and also in mercury vapor between nickel electrodes in cylindrical glass tubes of various dimensions, has been studied as a function of the vapor pressure. The results are analyzed with the aid of Pachen's law. Significant variations in the breakdown potential which depend upon the history of the tube preceding the breakdown are observed. The behavior of the discharge as an electrical circuit element has also been studied.

**E11. Ionization Potentials of Some Hydrocarbon Series.** RICHARD E. HONIG, *Socony-Vacuum Laboratories.*—A new method is described which permits ionization and appearance potentials to be determined reproducibly, within $\pm 0.02$ volt, by electron impact in a conventional 180° mass spectrometer. The energy spread of the ionizing electrons, while not eliminated, is accounted for in an analytical expression that describes the ionization efficiency curve of argon near the initial upward break. It is shown that an ionization or appearance potential can be determined graphically by drawing a tangent or critical slope to the efficiency curve which has been plotted on a semi-log scale. Absolute values are obtained by referring the unknown to the ionization potential of a calibrating gas (usually krypton). For the monatomic gases studied, electron impact and spectroscopic values agree within the experimental uncertainty. For some known polyatomic molecules, the "vertical" impact values exceed the "adiabatic" spectroscopic potentials by 0.02 to 0.2 volt, depending on molecular complexity. Paraffins, 1-olefins, and 2-olefins show a systematic reduction in potential with chain length. A similar decrease is observed when the monoolefins are arranged according to the number and size of substitutions on the basic ethylene structure.

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## TUESDAY AFTERNOON AT 2:30

### Judd Lecture Hall

(H. M. JAMES presiding)

**Z1. Dynamic Mechanical Properties of Rubber-Like Materials.** A. W. NOLLE, *Massachusetts Institute of Technology.*—The differential dynamic Young's modulus for representative rubber-like materials has been measured over a frequency-temperature range which at its widest limits extends from $10^{-1}$ to $10^{8}$ cycles per second and from $-50$ to 100°C. This dynamic modulus, measured for the case of small sinusoidal strain variations, is a complex number so that for each experiment both a real modulus and a loss-angle tangent are reported. Described are five methods of measurement which have been used to obtain natural frequency, resonant frequency, band width, decrement, etc. Methods include mechanical and magnetostrictive excitation. In addition the bulk wave modulus and its loss-angle tangent, at $10^{7}$ c.p.s., are measured by an ultrasonic-pulse method. The results show the existence of dispersion over at least six decades of frequency. The loss factor and complex compliance, as functions of frequency and temperature, are analyzed and discussed. The dynamic-modulus results, in the limiting case of very low frequency, below the range of appreciable relaxation effects, are shown to be in agreement with the kinetic theory of rubber-like elasticity. Compounds of buna-N, butyl, GR-S, Neoprene, and natural rubbers are considered, and characteristic differences are described. This work was supported in part under Contract NObs-25391, Task No. 1, with the Bureau of Ships.

**Z2. Method for the Absolute Measurement of Dynamic Properties of Linear Structures at Sonic Frequencies.** W. JAMES LYONS AND IRVEN B. PRETTYMAN, *Firestone Tire and Rubber Company.*—A full account, including the theoretical basis, is given of a method whereby the dynamic stretch modulus, coefficient of internal friction, and hysteretic energy loss of textile yarns and cords, composed of either continuous filaments or staple fibers, can be accurately determined at longitudinal-vibration frequencies above 100 cycles/sec. The method, which employs electromagnetic excitation, is applicable also to glass cords, and metallic wires and cables. Results have been obtained at frequencies extending to above 300 cycles/sec. A concise description is given of the improved stretch-vibrometer. Results on a typical cotton cord show that energy absorption by this instrument is negligible, permitting the calculation of an accurate internal friction coefficient, and absolute hysteretic loss. Measurements on eight natural and synthetic textile fibers reveal that the dynamic moduli range from $6.4\times10^{10}$ dynes/cm$^2$ for Velon monofil to $54\times10^{10}$ dynes/cm$^2$ for a ramie cord. The dynamic moduli of Fiberglas and steel cords were found to be $54\times106\times10^{10}$

dynes/cm², respectively. The internal friction coefficients are found to vary hyperbolically with frequency: in a 11/4/2 cotton cord, for example, from 1.5 to $8.0\times10^6$ poises between frequencies of 60 and 320 cycles/sec.

**Z3. Transducer Measurements of the Mechanical Properties of Polymer Solutions.** THOR L. SMITH, JOHN D. FERRY, AND FREDERIC W. SCHREMP, *University of Wisconsin.*—Apparatus has been designed for studying the mechanical properties of concentrated polymer solutions in small oscillating deformations, at audiofrequencies. A rod, driven by a coil in a magnetic field, oscillates vertically along its axis in a cylindrical tube of solution. The gap between rod and tube is 1 mm and the amplitude of vibration about 0.002 mm, so the maximum shear is very small and the maximum rate of shear moderately small even at 1000 cycles. By measuring the electrical resistance and reactance of the coil when in motion and when rigidly clamped, or when in motion with different masses attached to vary the inertia, the mechanical resistance and reactance of the system can be obtained from well-known transducer relationships. The former yields the real part of the dynamic viscosity of the solution, $\eta'$; the latter, under favorable conditions, yields the real part of the dynamic rigidity, $G'$. For polymer solutions, the viscosity $\eta'$ is found always to be very much smaller than the ordinary viscosity measured in steady flow. Examples of experimental data will be given.

**Z4. Geometric Disorder in Linear Polymers.** S. T. GROSS, *General Aniline and Film Corporation.*—Appearance of x-ray fiber diagrams is qualitatively related to single chains and groups of chains in the fiber sample. Several types of disorder can be localized in this manner. Some of the various types of geometric isomerism in polymers are considered, and in the general type of fiber diagram to be expected for each is noted. A number of polymers are discussed in relation to the above factors, and an explanation (based on the recently postulated restricted orientation of side groups)[1] is proposed for the non-crystalline structure of polyvinyl acetate and its hydrolysis to crystalline polyvinyl alcohol. Reasons for not obtaining a non-crystalline form of cellulose triacetate from this cause are considered.

[1] S. T. Gross, C. A. Schildknecht, A. O. Zoss, Am. Chem. Soc. meeting in New York, October 1947.

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TUESDAY AFTERNOON AT 4:00

Judd Lecture Hall

(L. A. WOOD presiding)

***Business session of the Division of High-Polymer Physics***

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TUESDAY EVENING AT 7:00

International House

***Dinner of the AAPT and the American Physical Society***

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WEDNESDAY MORNING AT 10:00

Eckhart Hall, Room 113

(R. S. MULLIKEN presiding)

**F1. On the Exact Solution to the Problem of Light Scattering by a Plane-Parallel Atmosphere in Accordance with Rayleigh's Laws.** S. CHANDRASEKHAR, *University of Chicago.*—The equations of radiative transfer allowing properly for the polarization characteristics of the radiation field and in accordance with Rayleigh's laws are formulated and solved exactly for the case of an incident parallel beam of radiation. The method consists in starting with certain functional equations governing the laws of diffuse reflection and transmission by a plane-parallel atmos-

phere, reducing them to a pair of functional equations of the standard form

$$X(\mu)=1+\mu\int_0^{1}\frac{\Psi(\mu')}{\mu+\mu'}[X(\mu)X(\mu')-Y(\mu)Y(\mu')]d\mu', \quad \text{(i)}$$

and

$$Y(\mu)=e^{-\tau_1/\mu}+\mu\int_0^{1}\frac{\Psi(\mu')}{\mu-\mu'}[Y(\mu)X(\mu')-X(\mu)Y(\mu')]d\mu', \quad \text{(ii)}$$

where $\Psi(\mu)$ is an even polynomial in $\mu$, and $\tau_1$ is the optical thickness of the atmosphere, and finally, relating in a unique manner the various constants occurring in the solutions with the moments of the $X$ and $Y$ functions appropriate for the problem. Rational approximations to the solutions of Eqs. (i) and (ii) can be obtained and starting with these approximate solutions the exact equations can be solved by iteration.

**F2. Theoretical Analysis of the Effect of Imperfections in Diffraction Gratings.** U. FANO AND R. D. HUNTOON, *National Bureau of Standards.*—It is of interest for the construction of diffraction gratings to estimate in advance the effect of imperfections in the spacing or shape of the grooves. Partial results in this direction can be obtained by an elementary theory in which each groove is considered as infinitely thin source of light. However, an extension of Rayleigh's dynamical theory of gratings makes it possible to develop a more general theory in which the nature of the approximations involved and their quantitative import are kept in sight. A complete account of this investigation will probably be published in the National Bureau of Standards Journal of Research.

**F3. An Electronic Eyepiece for Spectroscopy of Near Infra-Red.** ZABOJ V. HARVALIK, *School of Mines and Metallurgy, Rolla, Missouri.*—An electronic eyepiece for the observation of near infra-red of the spectrum is described. It can be attached to any spectroscope, and consists of an image tube of the type 1-P-25 which converts infra-red into visible images. The spectrum is projected by the telescope system of the spectroscope upon the mosaic face of the image tube. The infra-red radiation releases photoelectrons from the mosaic face of the image tube, which are focused by an electronic lens system upon a fluorescent screen. This fluorescent screen consists of a phosphor which, when activated by electrons, shows luminous characteristics similar to the sensitivity of the human eye. The visible range of a spectroscope, equipped with an electronic eyepiece, is extended to approximately $\lambda=1130$ m$\mu$ (11,300A) although very high intensity infra-red radiations can be observed to $\lambda=1145$ m$\mu$ (11,450A).

**F4. Fine Structure of He II λ4686.** J. E. MACK AND N. AUSTERN, *University of Wisconsin.*—The $3s^3S_1-4p^3P_1$ and $3p^3P_1-4s^3S_1$ components of the hydrogen-like spectrum of helium have been separated.

**F5. On the Structure of the Mercury Band λ2540.** S. MROZOWSKI, *Great Lakes Carbon Corporation.*—The well-known molecular band of mercury at λ2540 was studied with high dispersion (second order of the 30-foot University of Chicago grating). In absorption, only the long wave-length edge, two sharp maxima of absorption reported some time ago by Wood and Voss,* and a new short wave-length edge are observed. The band, however, could be obtained in emission using an exceptionally well water-cooled mercury arc in end-on observation. The whole band appears much sharper than in absorption. The long wave-length maximum is resolved into two very sharp components and a series of additional very sharp lines (or edges) converging toward the long wave-length edge are observed. The great sharpness of the emission lines (or edges) is hard to reconcile with the currently adopted classification of this band as a $^3O_u^+\rightarrow{}^1\Sigma_g^+$ transition in the $Hg_2$ molecule. The λ2482 band of the ionized mercury molecule $Hg_2^+$ was also studied and a complex structure of a number of maxima (edges) was detected.

* R. W. Wood and V. Voss, Proc. Roy. Soc. **119**, 689 (1928).

**F6. Force Constants and Assignments of the Raman Frequencies of Methylbromoacetylene and Methyliodoacetylene.** ARNOLD G. MEISTER, *Illinois Institute of Technology.*—Using the Wilson FG matrix method and a modified valence force potential energy expression, force constants for methylbromoacetylene and methyliodoacetylene were determined. The C−Br stretching force constant was found to be $4.024\times10^5$ dyne/cm while the C−I stretching force constant was determined as $3.376\times10^5$ dyne/cm. These values compare with $3.129\times10^5$ and $2.648\times10^5$ dyne/cm, respectively, for similar bonds in $CH_3Br$ and $CH_3I$ as given by Crawford and Brinkley.[1] As a result of the calculations it seems necessary to change some of the assignments of Cleveland and Murray[2] for the Raman frequencies of methylbromoacetylene and methyliodoacetylene. For both molecules the line near 690 cm$^{-1}$ does not appear to be a type $A_1$ fundamental frequency but more likely is the first overtone of the 343 cm$^{-1}$ type E fundamental. Also, the C−C stretching frequency probably was not observed since its calculated value was found to lie in the 970–990 cm$^{-1}$ region and Cleveland and Murray reported no line in this region for either molecule.

[1] B. L. Crawford, Jr. and S. R. Brinkley, Jr., J. Chem. Phys. **9**, 71 (1941).
[2] F. F. Cleveland and M. J. Murray, J. Chem. Phys. **11**, 452 (1943).

**F7. The Use of Photo-Tubes in the Ultraviolet Region by Fluorescence.** ROBERT D. COWAN,* *University of Chicago*—RCA multiplier photo-tubes types 931A and 1P28, sensitive down to about 3000A and 2000A, respectively,[1] have been used in conjunction with fluorescent materials for detecting light of wave-lengths as short as 1942A. From intensity measurements in the region 2300 to 3000A, first made directly with a 1P28, and then using the 1P28 in combination with the fluorescent material supplied by Eastman Kodak Company for sensitizing photographic plates, the efficiency of the fluorescence method has been estimated as about one forty-fifth. Of this, a factor of about twelve is geometrical in origin, and the remaining factor of three or four indicates a quantum

efficiency of fluorescence of roughly thirty percent. The 931A's in the writer's possession are five to ten times as sensitive as the 1P28's to the fluorescent radiation. They can thus be used as substitutes for 1P28's with the loss of a factor of only five or ten in sensitivity down to 2300A, and a considerable gain in sensitivity below 2100A. Use in the vacuum ultraviolet region has not yet been successful due to lack of sufficiently intense light sources.

* National Research Fellow.
[1] R. W. Engstrom, J. Opt. Soc. Am. **37**, 420 (1947).

**F8. Experimental Determination of Lorentz-Lorenz Correction in Ultraviolet Absorption.** LOIS E. JACOBS AND J. R. PLATT, *University of Chicago.*—Absolute absorption intensities were determined in the region 1750–2350A for isoprene, both in the vapor and in *n*-heptane solutions, using a small vacuum fluorite spectrograph. The apparent *f*-values computed from areas under the curves were 0.38 and 0.47 for the isoprene vapor and solution, respectively. Average deviation of individual intensity measurements were 6 percent for the vapor and 12 percent for the solution, with the integrated areas having an estimated error of less than 5 percent. These experimental *f*-values lead to a Lorentz-Lorenz correction of 1.23, which can be compared with the value of 1.32 calculated from Chako's theoretical formula. The difference of 8 percent is probably not significant. This discrepancy is much less than that obtained by Pickett and co-workers for the cyclic dienes. These studies are being continued on the *cis-* and *trans-*piperylenes.

**F9. Molecular Orbital Treatment of the Ultraviolet Spectra of Benzene and Borazole.** C. C. J. ROOTHAAN AND R. S. MULLIKEN, *University of Chicago.*—The ground state and the first excited states of benzene and borazole are treated according to the semi-empirical molecular orbital method. Comparing the observed spectra with the computed energies, a spectroscopic value of $-2.6$ ev for the bond integral $\beta$ is obtained in the case of benzene. In the case of borazole this procedure includes one more parameter, which takes care of the difference in electronegativity of boron and nitrogen. Taking a reasonable value for this parameter, a value of $-2.3$ ev for the bond integral between boron and nitrogen, $\beta^*$, is obtained in fair agreement with theoretical expectations.

**F10. X-Ray Optical Images.** PAUL KIRKPATRICK AND A. V. BAEZ, *Stanford University.*—When x-rays from a point source undergo total (not Bragg) reflection at a concave surface a real line image may be formed. If after one such reflection the rays impinge upon a second suitably oriented concave reflector a real point image may result. Real optical images of extended objects may thus be produced with x-rays. The method is analogous to the production of optical images by crossed cylindrical lenses. Spherical glass surfaces coated with gold or platinum, and having radii of curvature between 20 and 100 meters, have been successfully used, though the spherical form has been adopted for reasons of convenience rather than of theoretical superiority. Near grazing incidence a spherical mirror has practically the properties of a cylindrical mirror with focal length $Ri:2$, where $i$ is the grazing angle and $R$ the radius of curvature. The theoretical minimum distance between object points resolvable with x-ray mirrors, as the problem is now conceived, is of the order of 100A, though this resolution at present appears to be incompatible with high magnification. Theoretical resolving power is not strongly dependent upon wave-length. Optical systems with more than two mirrors have been used to attain desired magnifications and to improve image characteristics.

**F11. A Microphotometer for X-Ray Diffraction Diagrams.*** R. PEPINSKY AND H. I. WEST, JR., *Alabama Polytechnic Institute.*—A photometer is described for measurement of the integrated intensity of reflections on x-ray diffraction photographs. The film is placed against the face of a cathode-ray tube, e.g., a 5UP11 or 5FP5, and a finely-focused scanning electron beam on the fluorescent screen serves as light source. The beam sweeps linearly at 30 c.p.s. across the tube, and a 2-megacycle modulation is applied perpendicular to the slow sweep to produce a scanning ribbon, both the width and length of which can be controlled as desired. The transmitted light is received by a 931A photo-multiplier, the output of which is amplified and fed to the vertical plates of a second cathode-ray oscillograph. The horizontal sweep of the second c-r tube is linear and synchronized to the slow sweep of the first tube. Thus photometer traces of the x-ray reflections appear on the presentation tube. These can be recorded by tracing directly from the tube face. A procedure for electronic integration of these photometer traces is also described, the proper section of the trace being visually selected by two movable pips on the presentation tube; the voltage signals between these pips is fed to an integrating amplifier, the output of which appears as a meter reading. Measurements of the linearity of the photometer are presented.

* This development supported by Signal Corps Engineering Laboratories, Bradley Beach, New Jersey.

WEDNESDAY MORNING AT 10:00

Kent Theatre

(J. R. PLATT presiding)

***Joint Symposium of the AAPT and APS***
***Microwaves and their uses.***

**Absorption of Microwaves by Hydrogen Atoms.** W. E. LAMB, JR., *Columbia University.* (30 min.)

**Applications of Microwaves in Molecular Spectra.** WALTER GORDY, *Duke University.* (40 min.)

**The Production and Detection of Microwaves.** O. H. SCHMITT, *University of Minnesota.* (40 min.)

**Microwaves as Teaching Aids.** C. L. ANDREWS, *New York State College for Teachers.* (30 min.)

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## SUPPLEMENTARY PROGRAMME

**SP1. Viscous Slip along Grain Boundaries and Diffusion of Zinc in Alpha-Brass.*** T'ING-SUI KÊ, *University of Chicago.*—The viscous behavior of the grain boundaries in 70–30 alpha-brass was demonstrated by measurements of anelastic effects similar to those previously reported in the case for aluminum.[1] It was shown that the grain boundaries cannot sustain a shear stress and that they have a coefficient of viscosity decreasing with an increase of temperature. Using the same specimen, the activation energy associated with stress induced preferential orientation of pairs of zinc atoms in alpha-brass (which is a diffusion process), first observed by Zener,[2] was determined. It has a value of 40,000 calories per mole which is identical, within experimental error, to the activation energy of 41,000 calories per mole associated with the grain boundary slip in alpha-brass. This would indicate that the mechanism of the grain boundary slip in alpha-brass as manifested in the anelastic measurements is similar to the volume diffusion of zinc in alpha-brass.[3]

* This research has been supported by ONR.

[1] T. S. Kê, Phys. Rev. **71**, 533 (1947); **72**, 41 (1947).

[2] C. Zener, Trans. A.I.M.E. **152**, 122 (1943); Phys. Rev. **71**, 34 (1947).

[3] To be called for after Session G if time permits.

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**(To be sent to Professor J. W. Buchta, University of Minnesota, Minneapolis 14, Minn.)**

I EXPECT to attend the dinner of the American Physical Society at seven o'clock on Tuesday evening, December 30, 1947. My party will consist of ..... persons.

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